

DEPARTMENT OF THE INTERIOR

UNITED STATES BUREAU OF MINES
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DESIGN AND OPERATION
OF A
FOUR-TON-PER-HOUR GOLD AND SILVER ORE-SAMPLING PLANT



BY

E. D. GARDNER AND W. A. LEDDELL

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INTRODUCTION

During the summer of 1935 a plan was proposed by which the Government should establish custom sampling plants for gold and silver ores in the mining districts of the West, where the construction of such plants would be justified as an unemployment relief measure. It was known that in many districts prospectors and small operators had small lots of smelting ore that could not be marketed for lack of sufficient capital to get out enough ore at a time to make carload shipments to distant smelters. Moreover, considerable ore of milling grade was available in many districts in which there were no custom milling facilities. It was felt that accurate sampling and the classification and consolidation of small lots of ore produced from prospects and small mines, with quick cash returns to the shippers on a nonprofit basis, would stimulate the working of small gold and silver properties. Idle mines would be put to work, and there was a possibility that some of the prospects could be developed into regularly producing mines.

Each sampling plant was to be centrally located so as to serve the greatest possible number of mines and prospects. Wherever possible, the plants were to be built on a railroad. As ore of smelting grade accumulated, it was to be shipped to a smelter in carload lots. Where a plant was not on a railroad, smelting ore was to be trucked to the railroad after being sampled.

Ore of milling grade was to be shipped by truck or rail to existing custom mills, if such there were within shipping distance. Field surveys showed, however, that in some districts not at present served by custom mills enough ore probably could be obtained to supply local plants once mining operations were properly organized. Mill ore could be purchased and stock-piled for subsequent treatment in those districts. It appeared probable that after a few thousand tons had accumulated and further shipments seemed assured, private interests would build a local custom mill to treat the ore.

The authors were assigned the task of formulating standard plans for the custom sampling plants of the project; their findings are contained in this paper. Although the project was not finally approved, it is believed that publication of the plan together with discussion of general sampling-plant practices will be of assistance to those who may be considering establishing private sampling works.

ACKNOWLEDGMENTS

The authors acknowledge the assistance of the various machinery houses in the West, who kindly provided data concerning their products and quoted prices on equipment. The Mine & Smelter Supply Co. and the Denver Equipment Co. of Denver and the Southwestern Engineering Co. of Los Angeles also submitted estimates on the cost of a complete plant. W. O. Vanderburg, mining engineer of the U.S. Bureau of Mines at Reno, Nev., drew the plans for and estimated the cost of the assay office.

GENERAL PRACTICE AT SAMPLING PLANTS

Although ore continues to be sampled by hand, the general practice is to do the work mechanically. Moreover, automatic mechanical sampling is more economical than hand sampling.

The point to which mechanical sampling is carried before hand working begins depends upon the mechanical perfection of the devices employed, principally as to cleanliness and loss of fines. In the final stages of mechanical sampling, cleanliness and the mixing of fines are very important.

The object of sampling a lot of ore is to determine its true value. There is no reason, however, for sampling to a degree of accuracy beyond that to be obtained in assaying the final sample.

A difference of 0.01 ounce between two assays by the same assayer of the same sample is considered a good check, yet 0.01 ounce of gold at \$35 per ounce is worth \$0.35, or 5 percent of the value of \$7 ore. This percentage decreases, of course, as the value of the ore increases.

The samples obtained from lots of low-grade ore may vary by 5 percent of its true worth, but the discrepancy should be no greater than 1 percent on high-grade shipments.

Size of Products in Sampling

The fineness to which any lot of ore must be crushed before a predetermined proportion of its weight may be taken for a sample depends upon the size and grade of the lot and the distribution of the valuable minerals in it. Writers on the subject do not agree, and practices at sampling plants are far from uniform.

The problem has been attacked from both the mathematical and experimental sides. Taggart⁴ summarizes the results of various investigators.

Table 1, by Woodridge,⁵ based on extensive experiments and calculations by Brunton,⁶ may be used as a guide for a medium-grade (\$10-\$20) gold ore.

For example, as shown by table 1, a 1-ton lot of medium-grade gold ore should be crushed to 1 inch before a sample cut is taken. Should the ore be "spotty" or high grade, finer crushing would be required before the initial cut is taken. On the other hand, a 1-ton lot of uniform, low-grade ore need not be crushed to this size.

Taggart⁷ states that in sampling base ores the weights indicated in Woodridge's table probably may be multiplied safely by 10.

The size of crushing before each cut is taken at the contemplated plants discussed later in this paper is well within the limits set by Woodridge and other authorities. All lots would be crushed to 7/8 inch, and small lots of high-grade ore would be reduced to 1/4 inch before sampling is begun.

TABLE 1.- Smallest permissible weight of sample for varying sizes of crushing of medium-grade gold ore

Maximum size of products	Smallest permissible weight, pounds
2 inches.....	10,000
1 1/2 inches.....	5,000
1 inch.....	2,000
3/4 inch.....	1,000
3/8 inch.....	400
1/4 inch.....	300
3/16 inch.....	100
1/8 inch.....	75
6 mesh.....	50
10 mesh.....	25
18 mesh.....	10
30 mesh.....	4
50 mesh.....	1

4 Taggart, Arthur F., Handbook of Ore Dressing: John Wiley & Sons, Inc., New York, 1927, p. 1127.

5 Woodridge, T. R., Ore-Sampling Conditions in the West: Tech. Paper 86, Bureau of Mines, 1916, p. 57.

6 Brunton, I. W., Theory and Practice of Ore Sampling: Trans. Am. Inst. Min. Eng., vol. 25, 1897, p. 826.

7 Taggart, Arthur F., Work cited.

Size of Sample Cuts

Obviously, to obtain an accurate sample the size of the first cut must be governed by the size of the material to be sampled. For example, 1 percent of a very fine mill pulp may be sufficient to give accurate results for metallurgical control, while the same percentage of coarse ore would be not much more accurate than a grab sample.

By reducing the diameter of a cube of ore by one half, each fragment would be one eighth of the weight of the original cube. Theoretically, therefore, after each one-half reduction in size of the ore fragments, the minimum cut to be taken in sampling should be 12-1/2 percent. To allow for oversize getting through the crusher, probably 20 percent should be the minimum percentage considered for a cut after each one-half reduction. The percentage of the cut that may be taken safely for each intermediate size can be determined from Woodridge's table. The above was considered in the design of the proposed plants; the contemplated percentage for each cut would be ample.

The practice in regard to the size of cuts at different sampling plants varies greatly. The initial cut ranges from 5 to 25 percent, but is 20 percent at most plants. At the El Paso smelting plant of the American Smelting & Refining Co. five 20-percent cuts are taken, each after a reduction in size. The resultant product is mixed and quartered by hand for final grinding.

Moisture Samples

Accurate moisture samples are difficult to take, and generally are a bone of contention between the seller and the buyer of ores. The writers know of no entirely satisfactory method of taking moisture samples from run-of-mine ores. It would appear desirable that a sample for moisture determination should be taken at the time the ore is received and weighed, as some of the moisture in the ore will evaporate while the lot is being handled; on the other hand the ore may in some cases be rained upon between weighing and crushing. Obtaining an accurate sample at the time of weighing, however, depends upon the personal skill of the one taking the sample and may be no more than an estimate in many instances. Despite its limitations, this practice continues to be followed by many purchasers of custom ore.

At most plants where the moisture sample is taken on receipt of the ore, two or more holes are dug into the truck or car load after the top layer has been scraped off, and one or two 10-pound samples are obtained and placed in sealed containers until ready to be dried. Duplicate samples taken in this manner seldom check very closely. The principal chance for error lies in the fact that fines contain relatively more moisture than coarse material. Obviously, the personal equation cannot be eliminated; personal judgment must be depended upon to get a fair sample.

Occasionally grab samples for moisture are taken at the end of a conveyor belt from the primary crusher; if the ore has been thoroughly mixed before it reaches this point and a weightometer used on the conveyor, such a grab sample would reveal fairly accurately the moisture in the ore at the time the sample was taken. In most plants, however, little mixing of ore occurs in the initial crushing.

Fulton⁸ considers grab sampling unfair and recommends that the regular plant sample prepared for final grinding be used in determining the moisture and that allowance be made for evaporation of moisture in the passage of the ore through the plant; this is considerable and must receive consideration.

⁸ Fulton, Charles H., *The Buying and Selling of Ores and Metallurgical Products*: Tech. Paper 83, Bureau of Mines, 1915, p. 11.

According to Brunton,⁹ experiments have shown that the loss of moisture during machine sampling is about 10 percent in summer and 7 percent in winter in Colorado. Hence, an indicated, 5-percent moisture content of an ore sampled in the summer would contain actually 5.5 percent. He also states that 1 percent should be the maximum discount to be added to offset evaporation; if the sample contained 15 percent moisture, the deduction for moisture should be 16 and not 16.5 percent. Duplicate samples of relatively dry material should check within 10 percent.

Brunton's figures for loss of moisture in Colorado ores would be too low for damp ore in the Southwest, where summer temperatures are over 100°F. and relative humidity usually less than 20 percent during the day. Gold ores from near the surface in the Southwest usually contain about 1 percent water in dry weather. Some of the southwestern gold custom plants make a blanket deduction of 1 percent for moisture on all shipments in dry weather. Deductions for moisture in similar ores shipped to smelters usually range between 2 and 4 percent. Talcu ores from wet mines in the mountain regions may contain as much as 30 percent moisture.

Moisture samples are dried at a temperature of 212° to 250°F. until a constant weight is obtained.

PROPOSED METHOD OF SETTLEMENT FOR PURCHASED ORES AT CONTEMPLATED SAMPLING PLANT

Payment for purchased ores is based on the assays of the samples taken of the ores.

The final product from sampling a lot of ore generally is split into four 250-gram portions. One split is given to the shipper, one used for assay at the plant, one held for umpire, and the fourth for a recheck at the plant if needed.

Usually, if within certain limits, settlement is made on the average of the buyer's and the seller's assays; that is, the difference is split. If the discrepancy is beyond the limits set, a sample is submitted to an independent assayer for "umpire" determination. Should the result of the umpire fall between the disagreeing assays, this assay is taken as the basis of settlement. In this case the cost of the assay usually is shared between the buyer and the seller. Should the umpire assay be higher or lower, the one nearer the umpire assay is chosen for making the settlement; the loser pays for the assay. In some districts either the buyer or the seller may call for an umpire at any time irrespective of the difference between the two assays. Some purchasers of ore pay only on their own assay, except where an umpire is called for. In justification of this latter policy, it is pointed out that assay offices at most small mines generally are not properly equipped nor are competent assayers always employed, whereas up-to-date laboratories are provided by the purchasers and experienced assayers employed.

In assaying low-grade gold ores it was formerly considered that duplicate assays of the same sample by the same assayer should check within 0.02 ounce. With gold at \$35 per ounce, however, this difference is \$0.70 per ton, which appears to be too high. An attempt should be made to keep the discrepancy to 0.01 ounce per ton. Due to the inherent difficulties of assaying, however, results within 0.02 ounce can be considered a close check on the same sample of low-grade ore by two independent assayers. Obviously, therefore, differences within 0.02 ounce should be split. For high-grade ore a larger tolerance is allowable.

Control assays for low-grade silver ore should check within 0.2 ounce; for 50-ounce ore the discrepancy in the assays may be as much as 0.5 ounce.

According to Taggart,¹⁰ the usual splitting limits for copper ore are 0.2 to 0.5 percent; lead ore, 0.5 to 0.6 percent; and zinc ore, 0.6 to 1 percent.

⁹ Brunton, I. W., Theory and Practice of Ore Sampling: Trans. Am. Inst. Min. Eng., vol. 25, 1897, p. 826.

¹⁰ Taggart, Arthur F., Handbook of Ore Dressing: John Wiley & Sons, Inc., New York, 1927, p. 1127.

In the plans for administering the plants considered in this paper, it was proposed to buy the ore outright and dispose of it later unless the shipper should prefer to do his own marketing, in which case it would be sampled and returned to him. The sampling, treatment, freight charges, and metallurgical losses would be calculated for each lot purchased and the proper deductions made at the time of settlement. If doubt should exist as to the recovery that might be made on any lot of mill ore received, or the cost of smelting a concentrate, a part payment would be made on receipt of a lot and final settlement after the final returns were in.

When ore was purchased outright, it was planned to pay the shipper on the basis of the dry weight for each lot as soon as the assays were out. Settlement was to be made immediately for small and intermittent lots on the assay at the custom mill when the shipper had no facilities for making the assay or did not want to go to the expense of having it made by a custom assayer. When the shipper had proper facilities for assaying and a competent assayer, or wished to have his assaying done by a competent custom assayer, settlement was to be deferred until the shipper's assay was received; if an umpire was required, settlement would be further delayed. In special cases, however, 90 percent of the settlement price would be paid when the buyer's assay was out.

Settlement for gold ores would be made as follows: If the difference between the shipper's and the buyer's assays was 0.02 ounce or less per ton, this difference would be split on all shipments that contained 1/2 ounce or less per ton. On ores containing between 1/2 and 1 ounce of gold, a difference of 0.03 ounce would be split; and containing over 1 ounce, 0.04 ounce. On small lots, however, by mutual agreement greater differences would be split. When the differences in assays were greater than the above, a sample of the disputed lot would be sent to a competent assayer agreed upon by both parties for umpire. Settlement would be made on the umpire assay when the results obtained by the umpire fell between those shown by the buyer's and the seller's assays; the cost of the umpire assay would be divided evenly between buyer and seller. When the umpire assay was higher than the seller's the seller's assay would be used as a basis of settlement, and when lower, the buyer's. The loser would stand the cost of the umpire.

The splitting limits suggested by Taggart would be followed for determining base metals in the ores. For silver ores that contained up to 20 ounces per ton, differences up to 0.5 ounce would be split. On high-grade ore the same procedure would be followed when the differences in assay did not exceed 1 percent of the value of the silver. Greater differences would be umpired in the same manner as for gold ores.

ESTIMATED CHARGES AGAINST PURCHASED ORES AT CONTEMPLATED SAMPLING PLANT

It was planned to run the plants at cost; neither a profit was to be made nor losses sustained on any of the lots of ore received. To come out even, should the ore be purchased outright, the following charges would have to be made against each lot: (1) Cost of sampling; (2) cost of treatment and transportation of the ore after sampling; (3) metallurgical losses incurred during treatment; and (4) cost of smelting concentrates when made.

Cost of Sampling

The cost of sampling at the small plants contemplated would be relatively high. The tons per man-shift handled would be low, and as most of the plants would be in isolated locations, the cost of power and supplies would be high. The cost of sampling, exclusive of assaying, at large private sampling works in the West is about \$0.50 per ton; the cost at these small contemplated plants would be about three times that amount.

The proposed labor for running one of the contemplated plants on a one-shift basis with average wages would be:

Foreman - operator	\$7.00
Assayer - clerk.....	6.00
Operator.....	4.50
Crusherman.....	4.50
Dumpman.....	<u>4.00</u>
	26.00

At an average of 4 tons per hour for 8 hours daily, the labor cost would be \$0.81 per ton. When the plants run at part capacity or intermittently the labor cost would be higher. The plants discussed in this paper could handle considerably more than 4 tons of ore per hour if necessary, with a correspondingly lower cost per ton. Moreover the same crew could run a plant of several times that capacity.

Electric power would be used where available, but small gasoline or Diesel engines probably would be used at most of the plants contemplated. The sustained load would be about 26 kw. (35 hp.). At an estimated average of \$0.02 per kw.-hr., the power cost would be \$0.13 per ton. Supplies are estimated at \$0.07 per ton of ore sampled.

The average cost of plants, as is shown later, would be about \$20,000. Estimating the life of a plant to be 10 years and interest on the investment to be 4 percent, the yearly amortization would be \$1,666; for 9,600 tons per year (32 tons daily for 300 days), the cost per ton would be \$0.17. Cost of replacements would about equal cost of supplies, or about \$0.07 per ton.

Although charges for administration were not contemplated in the original set-up, such costs would have to be included for private plants; they, together with general charges, are estimated at \$0.10 per ton.

The estimated average total sampling cost per ton, then, would be:

Labor.....	\$0.81
Power.....	.13
Supplies.....	.07
Amortization.....	.17
Replacements.....	.07
Administration and general	<u>.10</u>
	1.35

If enough ore were available to warrant it, lighting facilities could be provided and the mill run on a two- or even three-shift basis, which would reduce the administrative and amortization charges per ton.

As the work of handling the end products of the sampling and the cost of assaying would be the same for both small and large lots, a higher rate per ton would have to be charged for the small lots. Probably a flat charge of about \$5 plus a fixed charge per ton would be made for each lot.

Cost of Treating Ores After Sampling

Smelter Rates

A part of the ore from the proposed sampling plants would be shipped to smelters.

Smelter rates in the West are competitive. Intermittent shipments of gold-silver ores usually are bought under open schedules. Commercial smelters, with both copper and lead furnaces, may have schedules for two or more classes of ore. In such cases, a shipper may sometimes choose the schedule that will bring him the highest return.

A base rate usually is quoted for each class of ore; the smelting charge increases with the value of the ore to a fixed maximum. Because of the advantages of receiving a steady supply of ore, smelters usually give lower rates to shippers who can contract a definite tonnage per month. When the same district is served by more than one smelter, concessions in rates can sometimes be obtained by bargaining. Special rates are offered by some copper smelters for siliceous gold ores, which are desired for their fluxing qualities or for converter linings. The minimum charge on this class of ore at one western copper smelter is \$1.50 per ton. Special concessions also are granted sometimes for other special types of ores.

Smelter tariffs for siliceous gold-silver ores.— Only smelters with copper furnaces purchase ores under this schedule. The minimum base treatment rate for siliceous gold-silver ores in the open schedules ranges from \$3.00 to \$8.50 at most western smelters; the maximum ranges from \$6.00 to \$15.00. From 90 to 95 percent of the gold, depending upon the grade of the ore and the practice at the smelter, is paid for at the mint price. Usually 95 percent of the silver, if over 1 ounce per ton, is paid for at the mint price if the proper affidavits showing the ore to be of domestic origin and newly mined (1935) are supplied. About 90 percent of the copper is paid for at the market quotation, less 2.5 cents per pound, with a further deduction of 10 pounds per ton at most smelters. No payment is made for lead. The ore may contain a maximum of 5 to 10 percent zinc without penalty. Penalties of 30 to 50 cents per unit (20 pounds) are charged for zinc in excess of that amount. Arsenic, if over 2 percent, is penalized at \$0.50 to \$1.00 per unit. Penalties are also charged for antimony, bismuth, and other deleterious metals. A charge averaging about \$1 per ton is made at most smelters for weighing, sampling, and other miscellaneous services. A special charge of \$10 is usually made for assaying and sampling small lots.

Smelter tariffs for gold-lead ores.— The base treatment charge for ores containing lead is usually lower than for ores shipped under the siliceous gold-ore schedule. Gold and silver are paid for in a similar manner. Like penalties are charged for zinc and other deleterious metals and, in addition, a penalty of 5 to 12 cents for each unit of insoluble (silica plus other insoluble material) in excess over iron in the ore is charged. Lime in the ore is credited at 8 to 10 cents per unit at some smelters. Usually 90 percent of the lead is paid for at New York quotations minus 1.5 cents per pound. At most smelters lead is not paid for unless the ore contains over 3 percent. All copper is paid for less 10 to 20 pounds per ton, and a further deduction of about 6.5 cents per pound is made from the New York quotation on the day of sale.

Freight Charges

Commodity rates on carload lots are established usually by the railroads when regular shipments of ore are to be made. A base rate for low-grade ore is quoted; an increase is made for regular increments in the value of the ore. Freight schedules are usually competitive, at least to some extent; the same rate may be established from a mining district to two smelters at different distances. The base freight rate on ore from western mining districts to smelters may range from \$0.25 to about \$8.00 per ton on main-line roads and up to about \$16.00 on branch lines. Usually it is cheaper to ship less-than-carload lots by truck from most western districts.

Milling Charges

Should mill ore be treated by custom mills in the district, the cost of trucking to the mill and the cost of milling must be charged against the ore sold.

Custom plants have been discussed in a recent paper by the senior author.¹¹ Custom charges, as shown in that paper, ranged from \$1.75 to \$9.60 per ton, depending upon the character and value of the ores treated, the milling method used, and to some extent upon what the traffic would bear.

Should a milling plant be built to handle the ore from the contemplated sampling works, the milling rates under average conditions are calculated to be about as follows:

Plant capacity	Rate per ton	
	Flotation	Cyanidation
50 tons per day..	\$3.00	\$4.00
100 tons per day	2.50	3.50

The above charges include amortization, overhead, and a milling profit of \$0.75 per ton. A deduction of \$0.25 per ton has been made on account of crushing the ore at the sampling plant. The direct costs included in the above figures are based on average costs in 1934 at a large number of gold mills of similar capacity in the West. With higher wage scales the labor costs would be increased.

If a satisfactory recovery could be made by amalgamation followed by table concentration, the milling rate would be less than for flotation.

Mills built to handle only the product from the sampling works would not need a crushing plant.

Metallurgical Losses in Mills

Obviously, only the metals saved in milling could be paid for. Based upon experience at small gold mills in the West, the recovery at cyanide plants would average about 92 percent, at flotation mills 87 percent, and at amalgamation plants 70 percent.

An estimate of the probable recovery would be necessary for each lot of mill ore received. In some cases a metallurgical test would be necessary.

The operators of most well-equipped custom mills are familiar with the different types of ores received and from past experience can anticipate closely the recovery that will be made on any lot. In such cases settlement is made on the assay value of the ore with standard deductions. Most small amalgamation and gravity-concentration custom plants turn over to the shipper the amalgam and concentrate from each lot after the milling charge is paid.

Cost of Smelting Concentrates

Where milling ores are purchased outright, allowance must be made for the cost of smelting flotation or table concentrates. The cost to be charged against each ton of a lot as received will depend upon the ratio of concentration, transportation, and smelter rate; it will average about \$0.25 per ton of gold ore milled. Special schedules are issued by some smelters for treating concentrates; usually, however, the same tariffs apply as for crude ore.

¹¹ Gardner, E. D., Gold and Silver Custom Plants: Inf. Circ. 6842, Bureau of Mines, May 1935, 4 pp.

Summary of Charges

As previously indicated, the charges against any lot of ore purchased by a sampling plant depend upon a variety of factors. The return for each lot must be figured separately.

As an example, the indicated direct charges and indirect deductions under average conditions at a sampling plant purchasing 32 tons per day of one type of \$12 gold ore, which would be milled in a nearby 50-ton flotation or cyanide custom plant, would be:

	<u>Milling method</u>	
	<u>Flotation</u>	<u>Cyanidation</u>
Direct charges, per ton:		
Sampling charge.....	\$1.35	\$1.35
Trucking.....	.25	.25
Milling.....	3.00	4.00
Transportation and smelting concentrate	.25	
Total.....	4.85	5.60
Indirect deductions, per ton:		
Milling loss.....	a/1.56	b/.96
Smelter deductions on gold in concentrate.....	c/.84	
Total.....	2.40	.96
Grand total.....	7.25	6.56

a/ 13 percent of \$12.

b/ 8 percent of \$12.

c/ 8 percent of \$12 minus 1.56.

The net return to the shipper of a flotation ore would be \$4.75 (\$12 minus 7.25) per ton and of a cyaniding ore \$5.44 (\$12 minus 6.56) per ton.

The average freight and smelting charges on \$12 gold ore in western districts would be about \$9 per ton, which would leave only \$3 per ton for mining, trucking, and royalty charges. This grade of ore could be shipped profitably to a smelter only when concessions are given in the smelter tariffs, or when the freight rate is relatively low, or both.

The gold ore shipped to smelters under present conditions has an estimated average value of about \$30 per ton. The smelting and freight charges on this class of ore from most western camps average about \$11.50 per ton, including a 5-percent deduction in the price of the gold.

If purchased in small lots by the proposed sampling plants, the charges to the shipper would be:

Sampling.....	\$1.35
Smelting and freight	11.50
	12.85

The net return to the shipper would be \$17.15 per ton.

If the same ore is milled in a 50-ton plant, the charges to the shipper would be:

Charges	Milling method	
	Flotation	Cyanidation
Sampling.....	\$1.35	\$1.35
Trucking.....	.25	.25
Milling.....	3.00	4.00
Mill losses.....	3.90	2.40
Transportation and smelting concentrate	.40	0
Smelter deduction on gold (5 percent)....	1.50	0
Total.....	10.40	8.00

The net return to the shipper of a flotation ore would be \$19.60 and to the shipper of a cyanide ore \$22.00 per ton. The shipper would get a higher return in both cases, under average conditions, if the ore were milled.

DESIGN OF PLANT

The authors were assigned the task of drawing standard plans for sampling plants that were to be built throughout the West under a wide range of natural conditions. The plans herein presented are for a plant on a level site, which is the most expensive from a construction viewpoint. The standard design used, however, could be adapted readily to slopes of various degrees.

The general layout of the sampling works is shown in figure 1.¹² The site shown is 330 by 330 feet and contains 2-1/2 acres. The arrangement of structures could be altered to fit plots of other shapes or sizes.

Provision is made in the standard plans for receiving the ore by trucks only. Any shipments that might be received by rail would have to be transferred to trucks for hauling to the receiving bins. As shown in figure 1, the purchased ore, after sampling, would be shipped by rail. Some of the contemplated plants, however, would not have rail connections; in such cases it was expected that smelting ore would be trucked to a railroad or a smelter. Mill ore would be trucked to local custom milling plants or stock-piled for future treatment.

It was expected that ore would be received in 1- to 20-ton lots. The ore would be weighed on a 9- by 22-foot, 15-ton platform scale and then dumped into the receiving bins.

The flow sheet of the sampling plant is shown in figure 2.

Approaches to Receiving Bins

Figure 3 is a detailed drawing of the approaches to the receiving bins. The ramps can be built in curved form if the site favors that construction. The radius of curvature of the part of the ramp carried on bents should be not less than 150 feet; the outside stringer on the outside of the curve should not have a span greater than 13 feet. The earthen part of the ramp, as shown in figure 3, may have a radius of curvature of 50 feet. If the works are built on a sloping site and the length of the incline is reduced by using a curved ramp, it is estimated that the economic point to which the earth fill may be carried is 8 feet.

¹² The full-size tracings of the figures used in this paper are on file at the Southwest Experiment Station of the U.S. Bureau of Mines, where they are available for inspection.

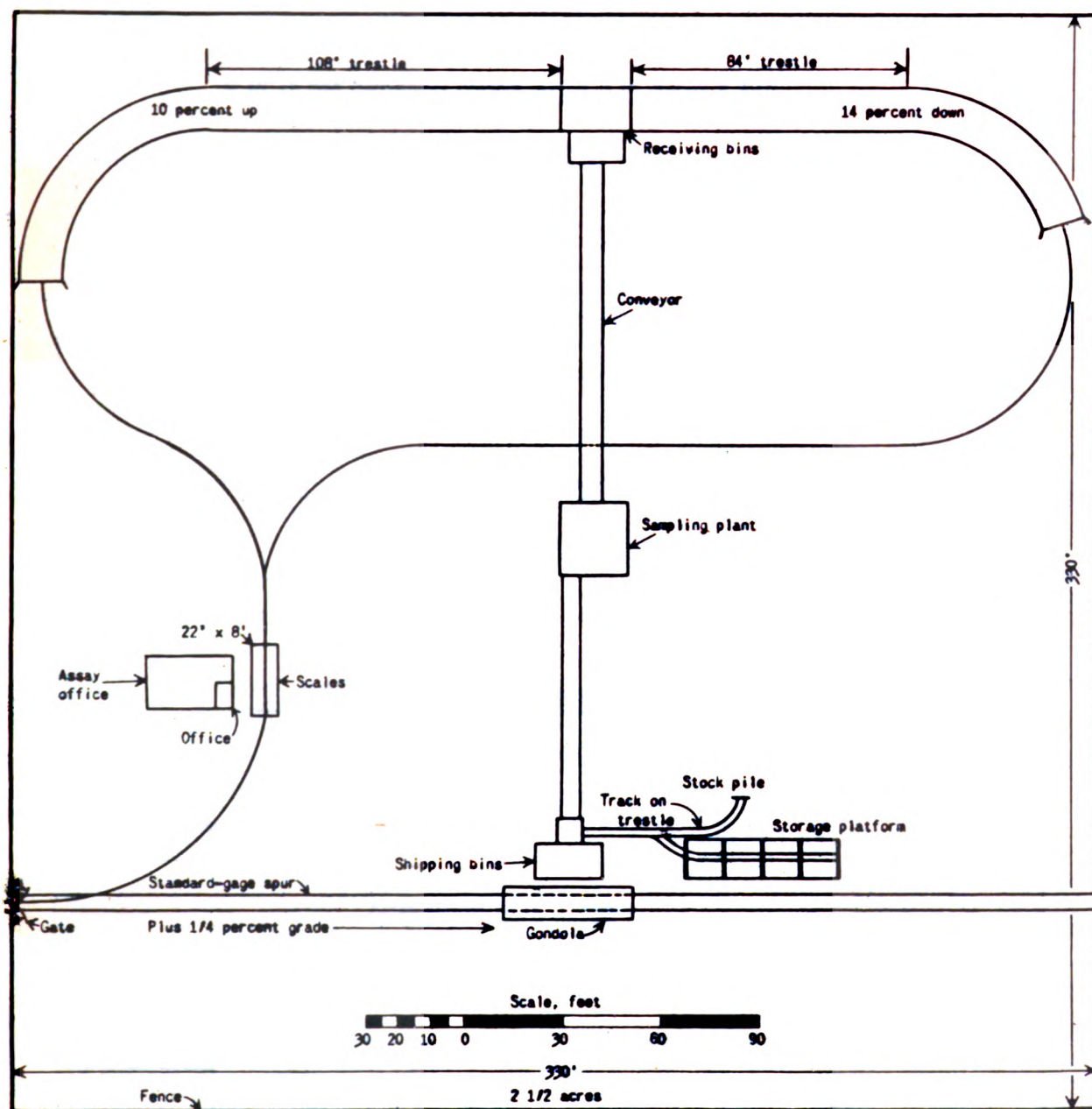


Figure 1.- General lay-out for sampling plant.

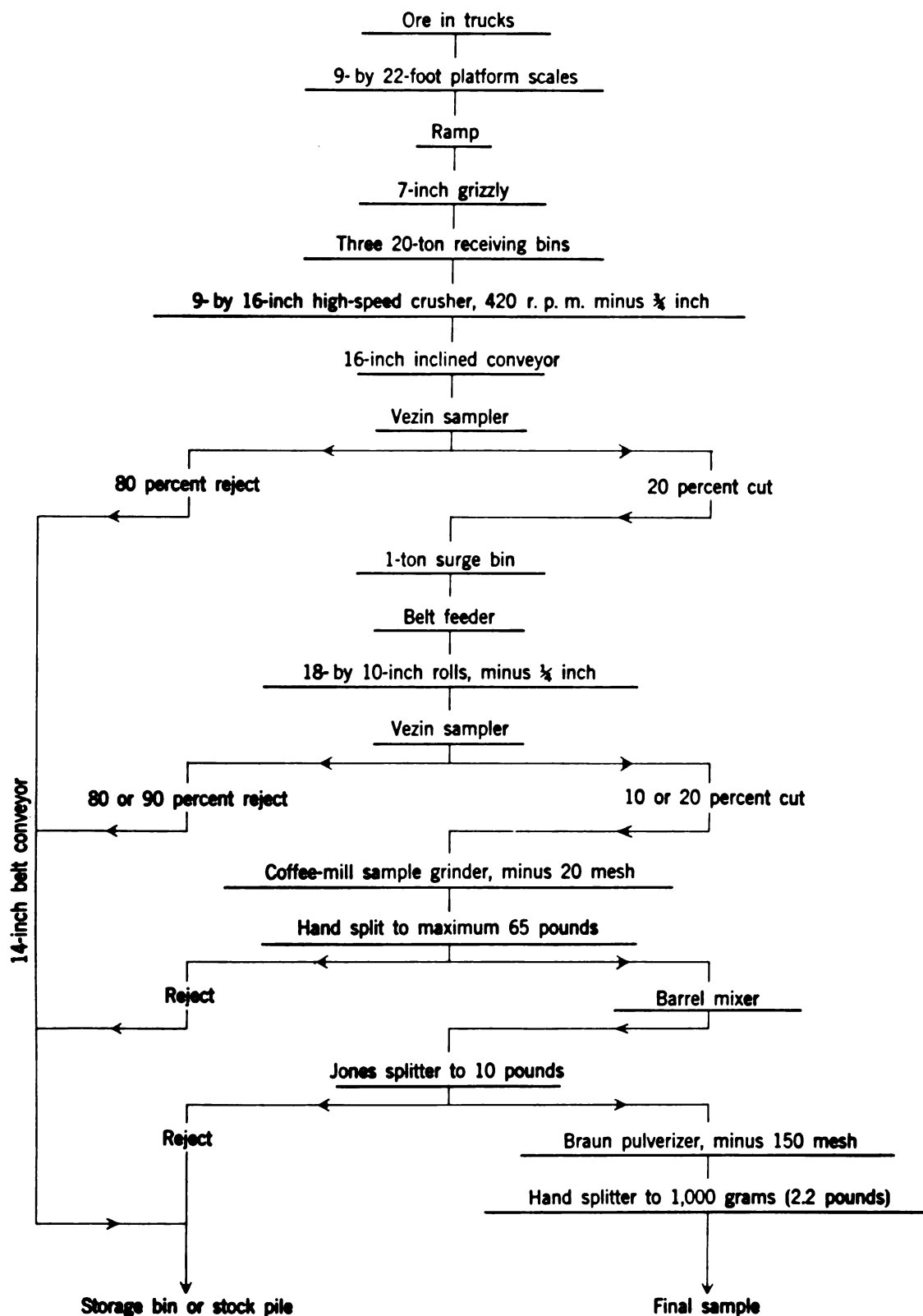
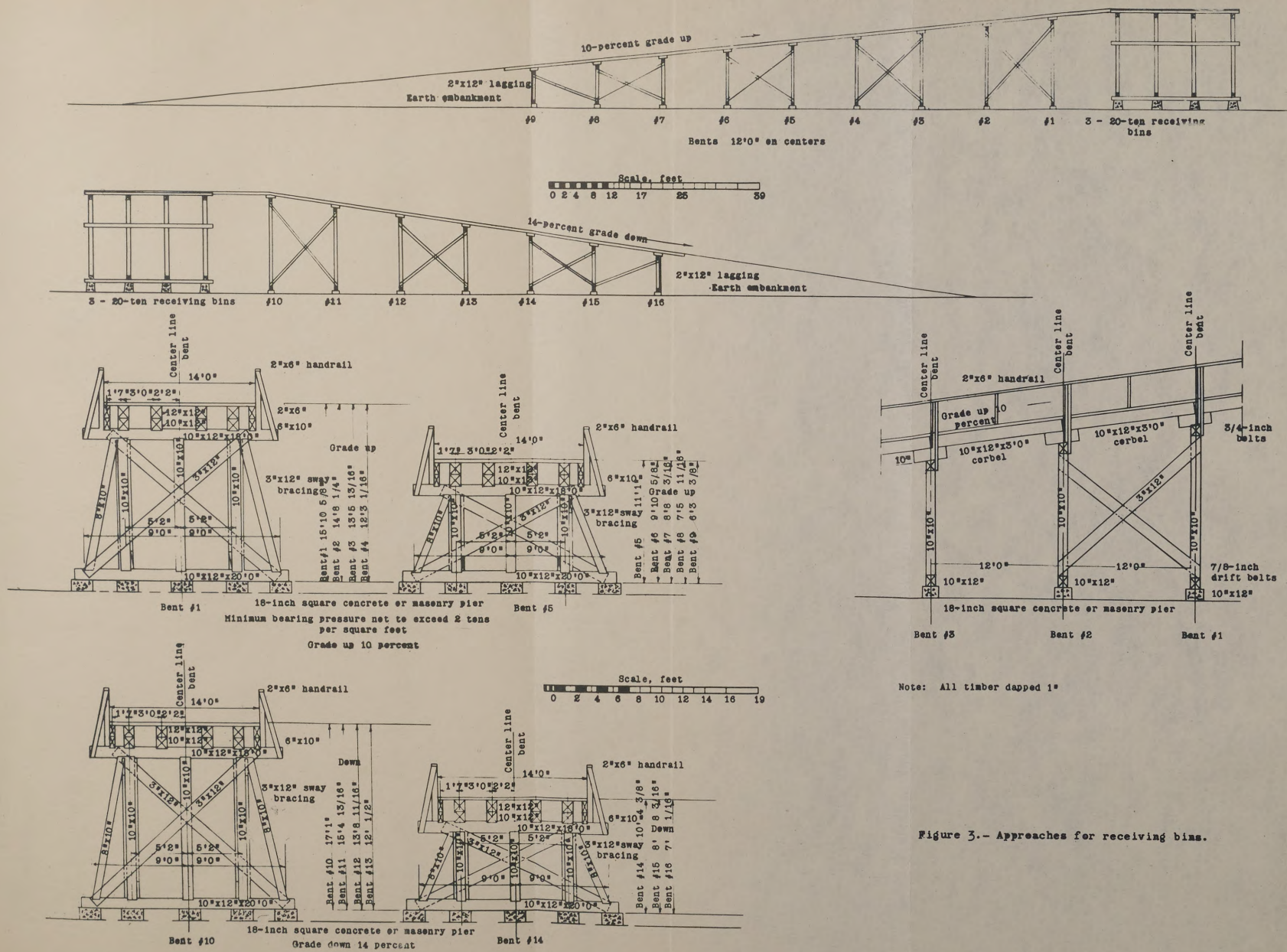
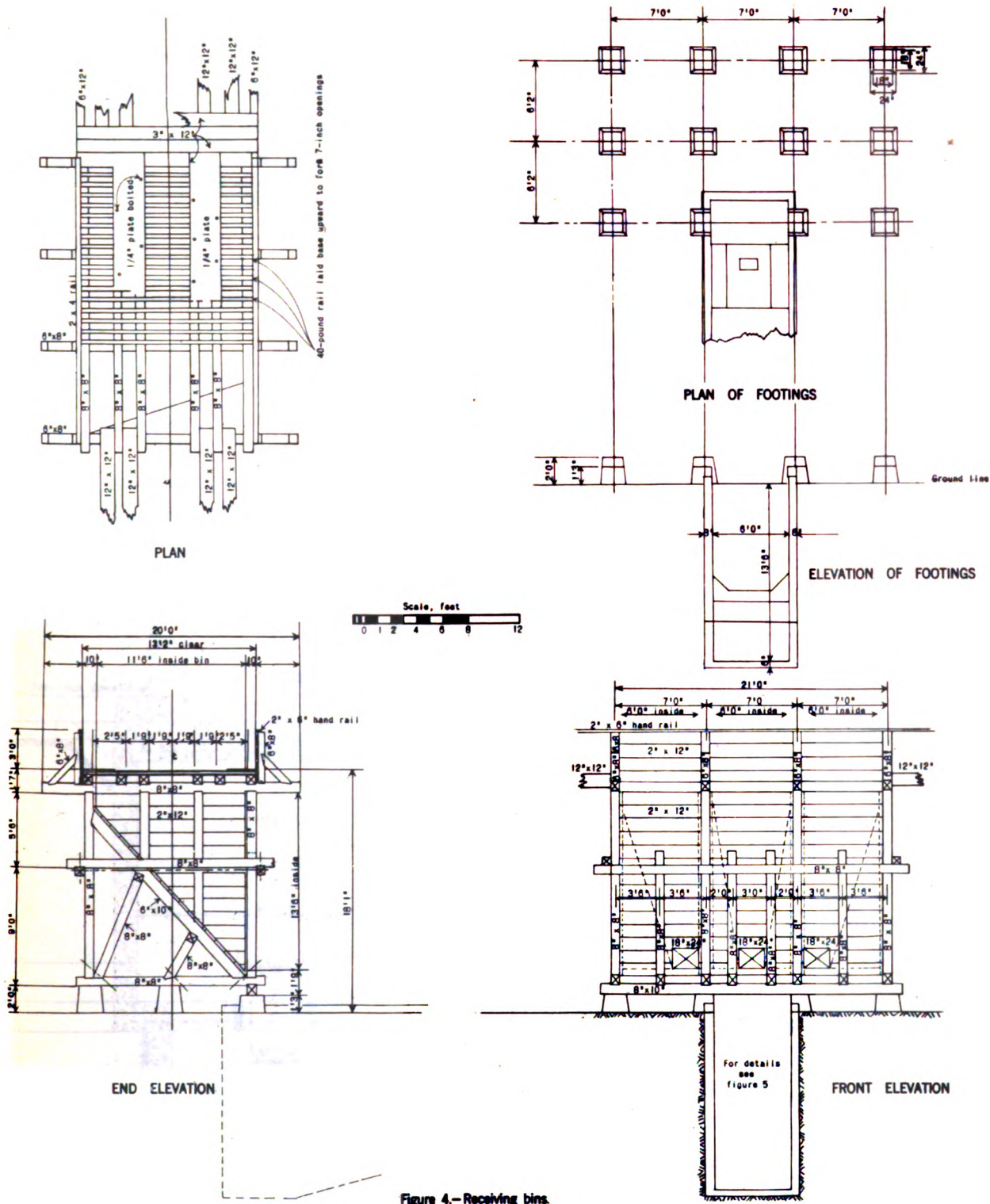
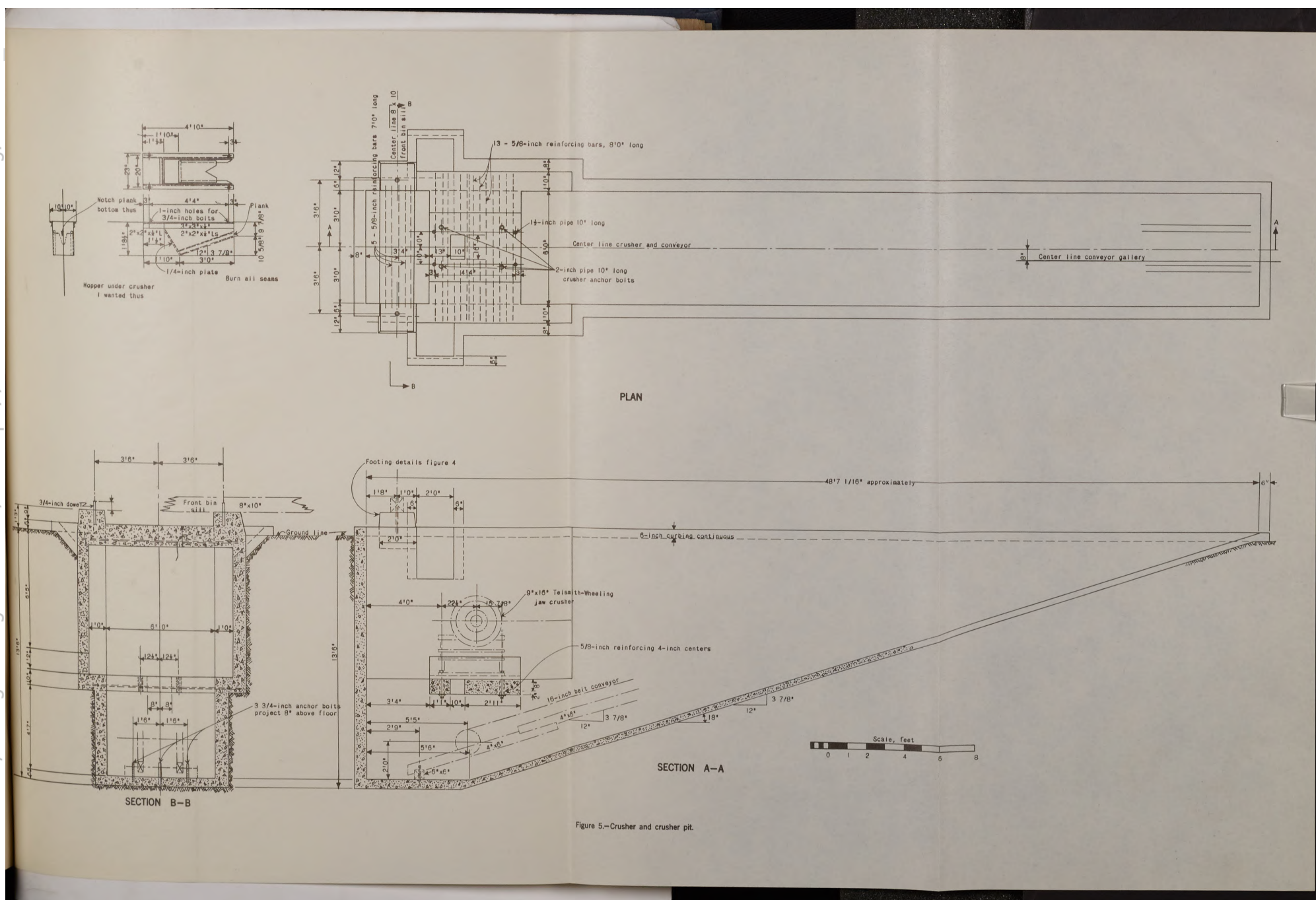


Figure 2.—Flow sheet of proposed Government sampling plant.







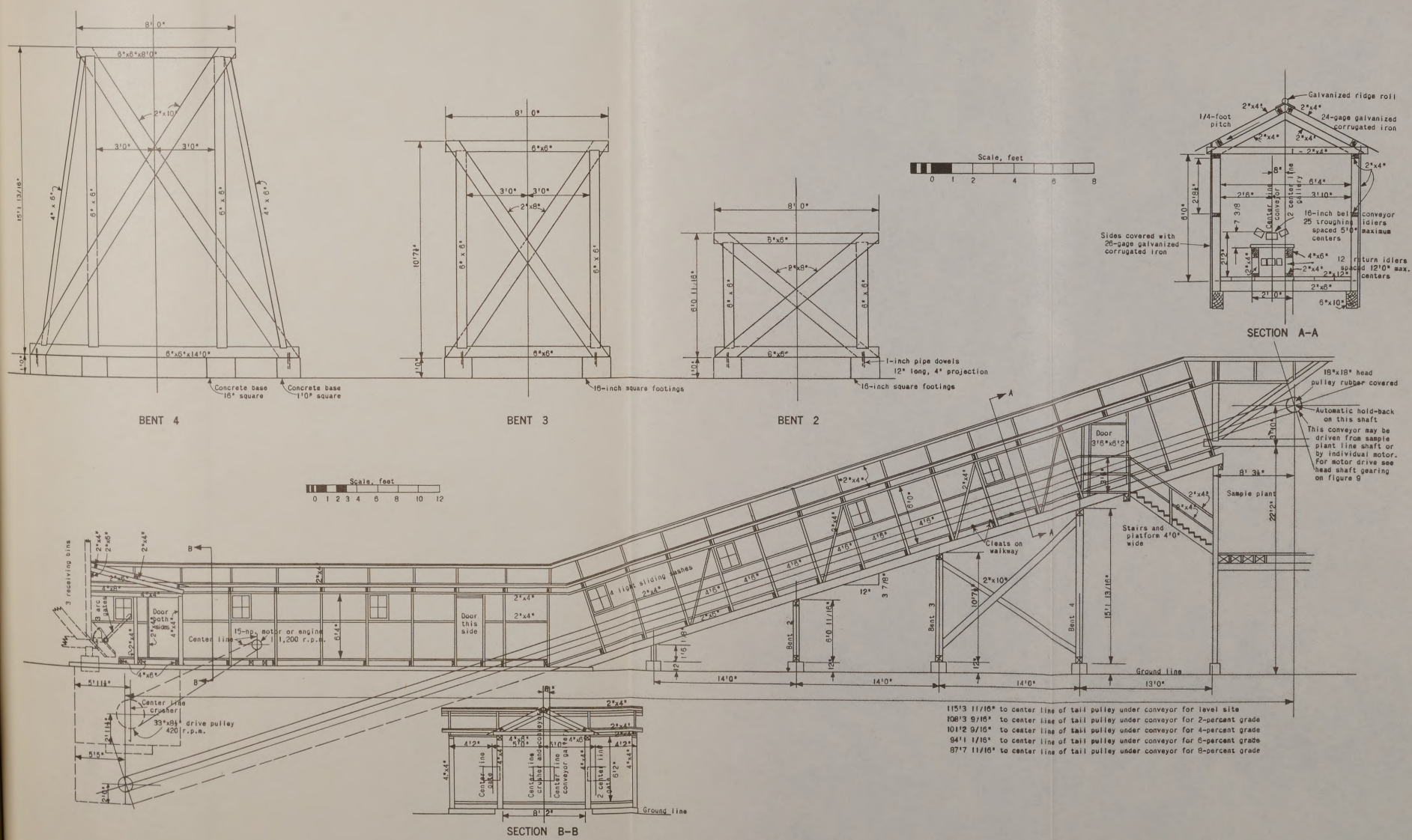
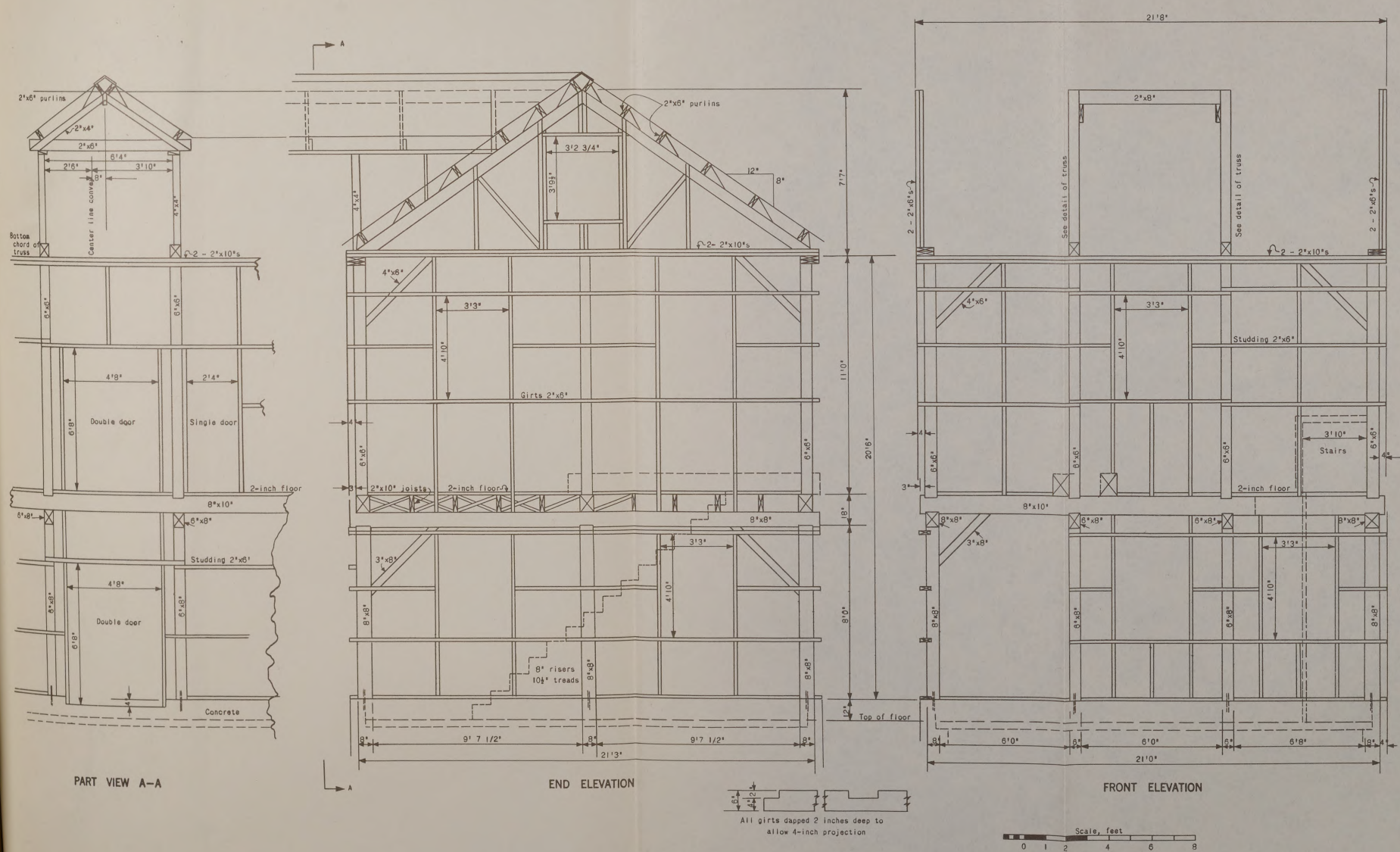


Figure 6.—Conveyor gallery from crusher to sampling mill.



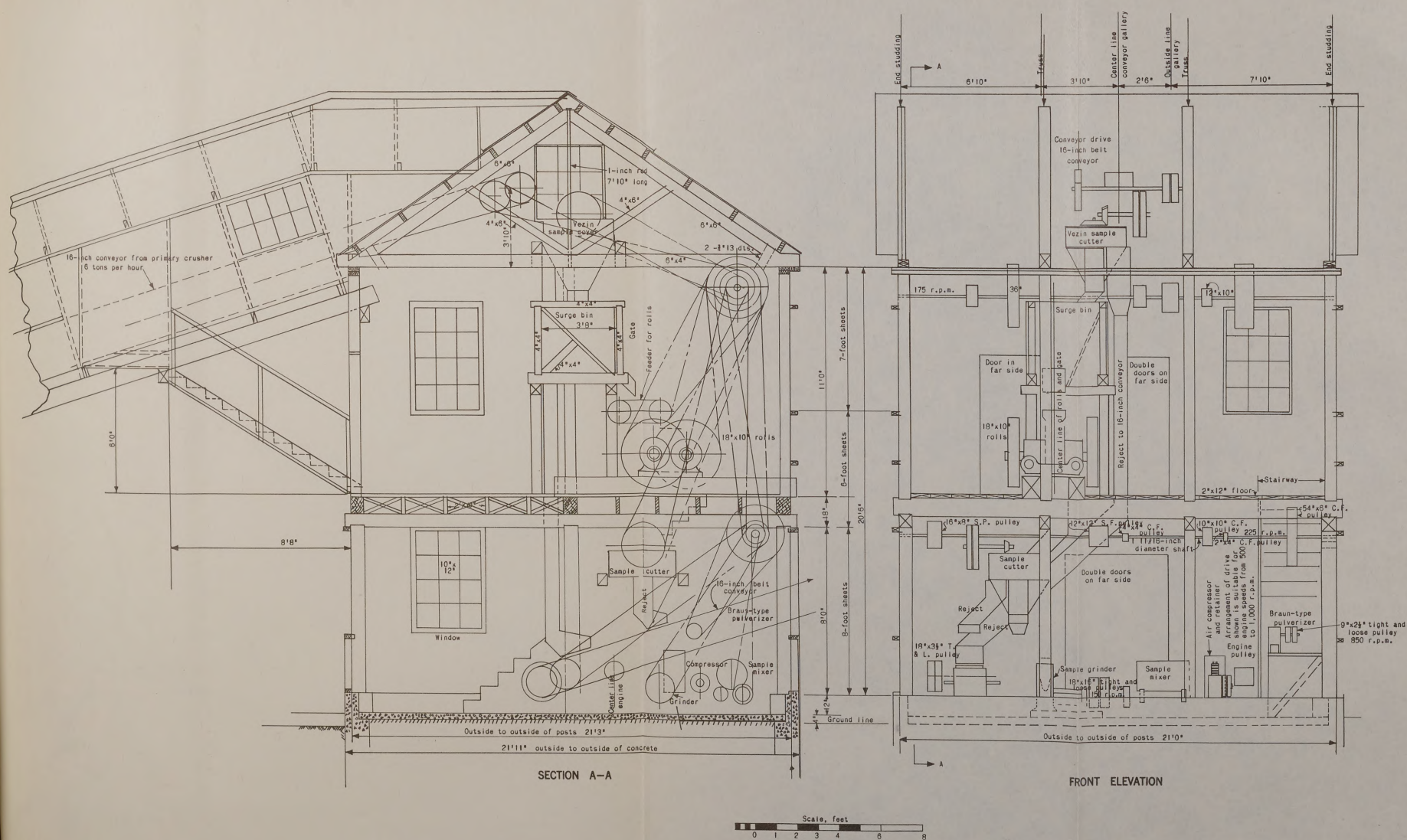
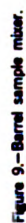


Figure 8.—General arrangement of sampling mill.



Receiving Bins

As it was expected that shipments would be received from a number of properties, provision was made for receiving ore from three shippers at a time. Three pockets with a capacity of 20 tons each are provided. All of the pockets could be used for the same lot, but few lots of over 20 tons were expected. The bins are self-cleaning. The details of the receiving bins are shown in figure 4.

A considerable saving in cost of construction could be made by eliminating the receiving bins and their approaches and substituting a small pocket or sloping platform at the coarse crusher. In this latter case a truck would be backed up a short earth ramp and its load dumped at the crusher. Ore from only one shipper could be received at one time.

Crusher

To save height in the receiving bins, the crusher was placed in a pit, as shown by figure 5. The gates of the receiving bins are so arranged that the ore can be fed directly into the crusher. Arc gates with 3-foot, 3-inch handles control the flow of ore. The operator at the crusher can stand on a platform at the crusher and manipulate the gates.

A high-speed, 9- by 16-inch crusher was chosen for the plant. It has a special toggle with two parts held together by rivets, which would shear if any tramp iron should get into the machine. This crusher can take any pieces of ore that pass through the 7-inch grizzly on top of the receiving bin and make a product that can be handled through a set of 18-inch rolls. The high ratio of reduction permits the omission of one crushing stage in the flow sheet of the plant.

According to the manufacturer's rating, the crusher has a capacity of 4 to 5 tons per hour, with a 5/8-inch discharge opening; with a 1/2-inch opening it is rated at 3 to 4 tons per hour, and at 5 to 6 tons per hour with a 3/4-inch discharge.

For the purpose of this paper it is assumed that the machine would have a capacity of 4 tons per hour with a setting that will pass particles with a maximum size of 3/4 inch, and will use a maximum of 15 hp.

The flow sheet of the mill was arranged for fairly high-grade ore. Should a larger hourly capacity be desired, the crusher and rolls could be opened to give a coarser product that would still be within the limits prescribed for accurate sampling of low- or medium-grade ores.

Conveyor to Sampling Mill

The conveyor and the conveyor gallery, with details of construction, are shown in figure 6. The housing on the crusher also is shown in that figure.

Sampling Mill

The details of the building to house the sampling mill are shown in figure 7. The general arrangement of the equipment in the mill, designed for a line-shaft drive, is shown in figure 8. This is discussed further under "power."

All equipment is standard and may be purchased from dealers of mining machinery, except the sample mixer, which would have to be made to order. The details of this mixer are given in figure 9; it is copied from one in use in the sampling plant of a southwestern custom smelter.

The ore to be sampled comes into the top of the plant by the conveyor and passes through a Vezin sampler. A 20-percent cut taken by the sampler drops into a 1-ton surge bin. The

reject drops onto another belt conveyor, which takes it to a storage bin. From the bin the ore is fed by a belt feeder into 18- by 10-inch rolls, which are set 1/4 inch apart, and thence to another Vezin sampler. This sampler is so arranged that a 10- or 20-percent cut may be taken. As before, the reject goes to the conveyor. The cut from the second sampler goes to a sample grinder, which reduces it to minus 20 mesh.

The product from the sample grinder for each lot is accumulated and then cut down by hand on a large Jones splitter to a maximum of 65 pounds. This is mixed thoroughly in the barrel mixer and then cut down to 10 pounds on another Jones splitter. Should lots of 20 tons or over be run regularly, a mechanical sampler would be desirable after the grinder. The mixed sample is dried and then put through a laboratory pulverizer, which grinds it to 150 mesh. The ground pulp is then mixed by hand and split to 1,000 grams (2.2 pounds). The final product is used for assaying.

A moisture determination of the ore would be made at the time the sample is dried. This would be checked against the moisture determination made of the crude ore as received.

Conveyor to Storage Bins

The conveyor for taking away the rejects from the plant, and the conveyor gallery with construction details are shown in figure 10. The drawing shows the drive for the conveyor at the upper end, which is standard practice. Although not standard practice, the conveyor could be driven from the line shaft in the sampling plant; in this case the drive mechanism shown in figure 10 would be placed on the lower pulley of the conveyor in the sampling plant.

Should the works be built on sloping ground, there would be a saving in the cost of the plant, as the length of the two conveyors and the conveyor housings would be less. The reduction in length of the conveyors for slope of 2° to 8° is shown in figure 6.

Storage Bins

Provision is made in the design of the plant for handling several types of ores. Figure 11 is a detailed drawing of the proposed storage bins.

The ore could be deflected into any of the three bins by a gate arrangement at the end of the conveyor. The main bin (A) holds a carload (50 tons) and would be used for the principal type of shipping ore handled. Irregular lots of shipping ore would be dumped into bin C and thence trammed by hand to the platform shown in figure 1. The platform is large enough so that 50-ton lots of two different types of ore may be accumulated at the same time.

Mill ore that might be accumulated for future disposal would be trammed from bin C to a dump, as shown in figure 1. Should two classes of mill ore be received, a second stock pile could be used. As the tramping tracks are on a trestle, no shoveling would be required in stockpiling ore either on the platform or in the dumps. Ore from bin C could also be loaded into trucks.

Bin B would be needed only when the site had sufficient slope so that stock piles could be built up without shoveling. This bin could be omitted at most sites, with a saving (\$55) in the cost of the structure.

POWER

The determination of the most satisfactory kind of power to be used in small milling plants usually is a difficult problem, and several factors must be balanced against each other.

Three alternate methods of driving the sampling plants were considered: (1) By purchased power, (2) by Diesel-electric power, and (3) by gasoline engines.

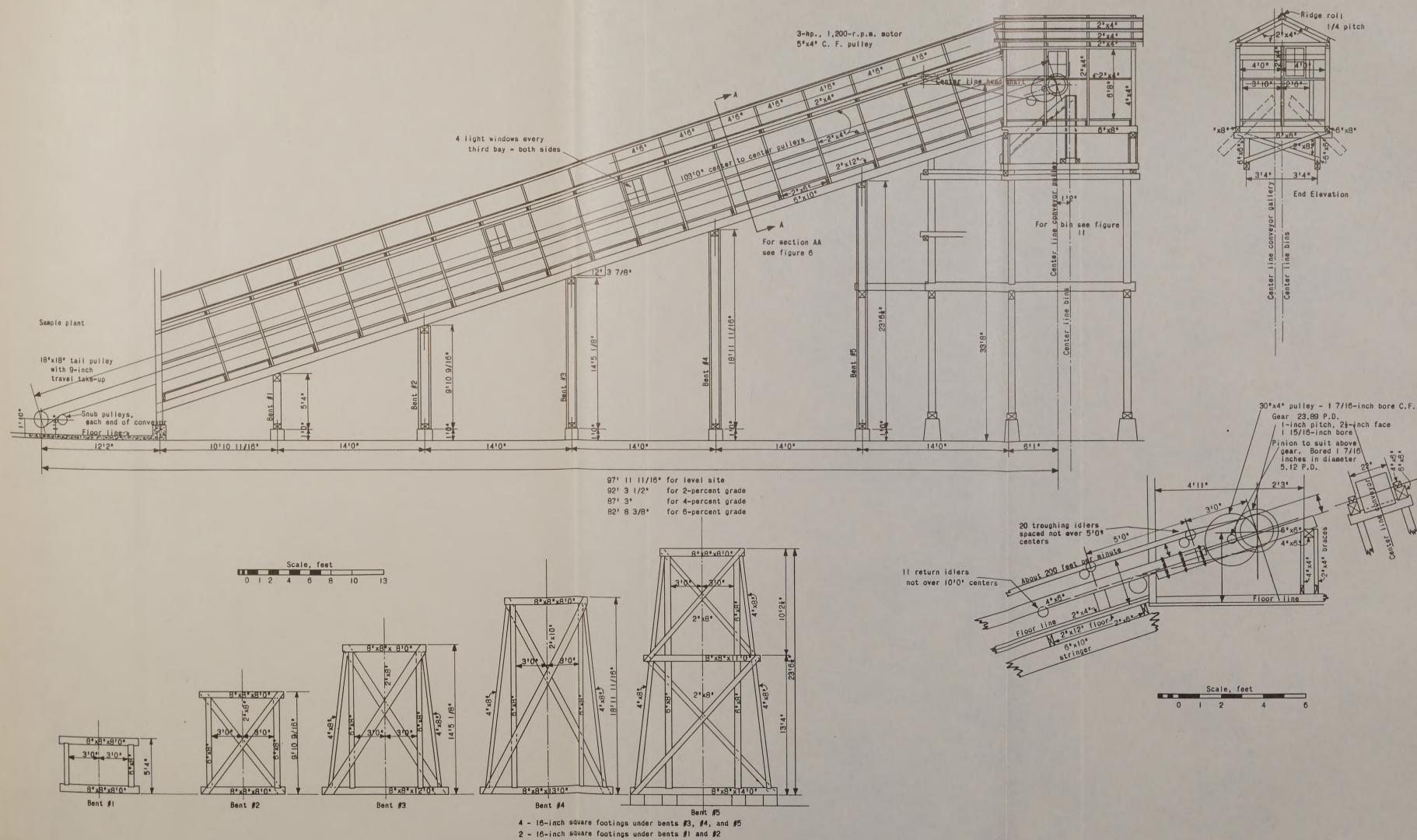


Figure 10.—Conveyor gallery from sampling plant to storage bins.

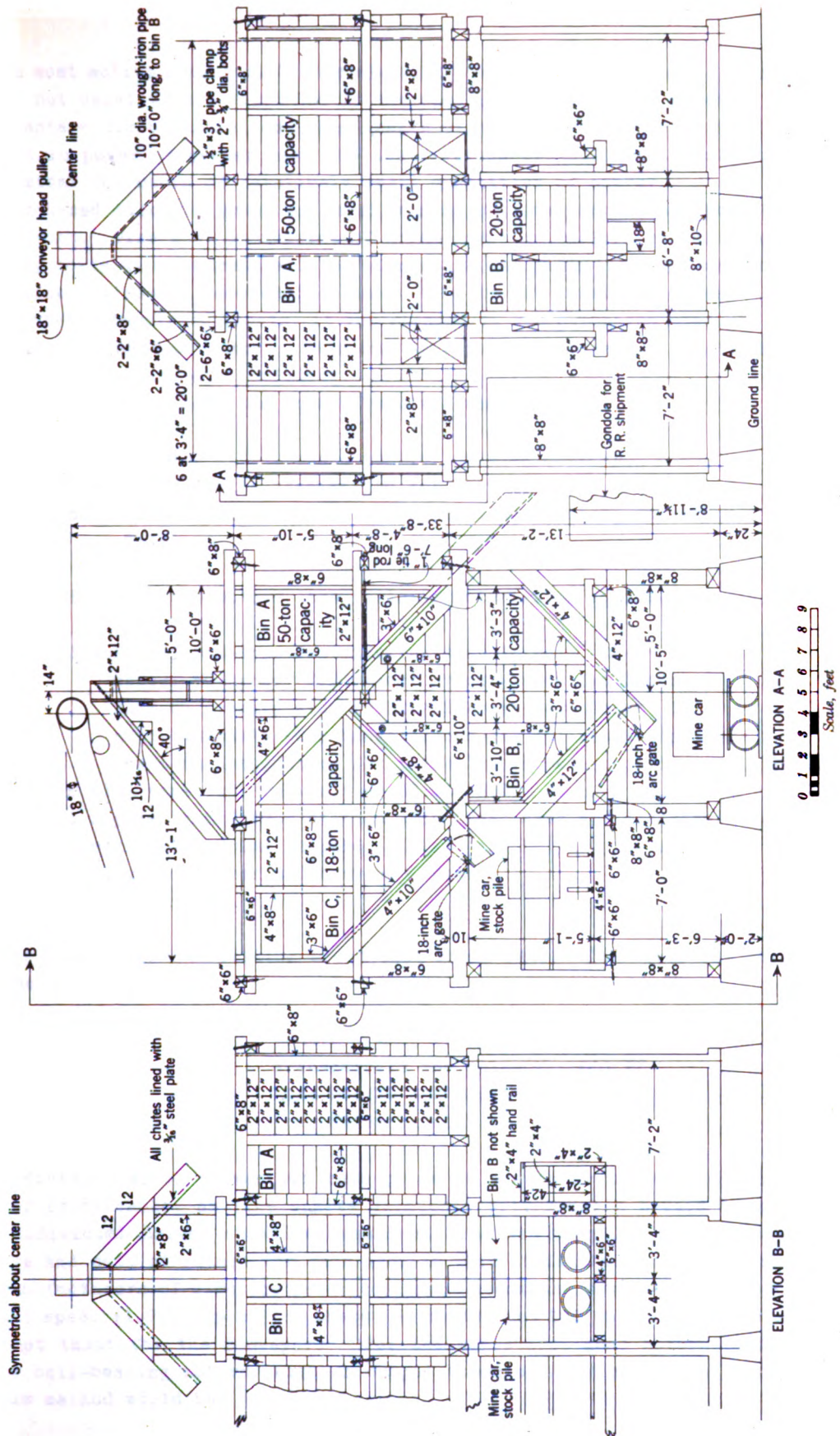


Figure 11.—Storage bins.

In most active mining districts electric power may be purchased from public utility companies, but usually this would not be the case in the districts in which the proposed sampling plants would be installed. The length of power lines required from the nearest source of electric power, together with the installation costs, usually make this form of energy uneconomical for users of relatively small quantities of energy.

Purchased electric power is usually more satisfactory than other forms of energy for small plants. Time lost on account of break-downs or failure of the power plants increases operating costs at most small milling plants. Although no trouble is experienced with Diesel or gasoline engines at some small plants, this is not usually the case.

In the contemplated plants, it was planned to use purchased electric power if available within a reasonable distance. As shown by figure 8, estimates were made for a line-shaft drive in the sampling-mill building.

The size and cost of the motors required would be:

15-hp. motor with accessories for driving crusher.....	\$181.57
40-hp. motor with accessories for driving plant.....	440.86
5-hp. motor with accessories for driving discharge conveyor..	<u>256.74</u>
Total.....	879.17

In addition to the motors, the following electrical equipment would be required:

3 conventional-type distributing transformers, 15-kv.-a., 1-phase, 60-cycle, 2,200-volt primary with two 5 percent taps on primary side to 220/110-volt secondary. The cost, complete with hanger irons and oil and freight allowed to designation for three, would be.....	\$479.88
6 plug-type fuse cut-outs at \$2.00 each.....	12.00
1 2-pole transformer station with cross arms and platform.....	45.00
Distribution poles in yard.....	75.00
Wiring to crusher and conveyor motor.....	<u>40.00</u>
	651.88

The line shaft and belting would cost about \$445. The total for this method of drive would be:

Motors.....	\$879.17
Transformers and poles..	651.88
Line shafts and belting	<u>445.00</u>
Total.....	1,976.05

Individual motor drives for each piece of machinery in sampling plants are desirable whenever practicable, as line shafts with belt drives are a hazard to the workmen. Moreover, individual drives occasion less lost time and simplify the operation of the plant. The size and cost of motors for each machine with individual drives are shown in table 2.

Manufacturers of electric power equipment recommend squirrel-cage induction motors with constant speed (1,750 r.p.m.), 3 phase, 60 cycle, and 220 volt for all motors shown in table 2, except those for the conveyors. For the conveyors, gear motors equipped with general-purpose ball-bearing motors, with an output speed of 41 r.p.m., are recommended. The cost for this method would be:

Motors.....	\$1,239.03
Transformers and poles..	651.88
Extra wiring.....	100.00
Total.....	1,990.91

TABLE 2.- Horsepower, r.p.m., and costs of motors for individual drives

	Horsepower	Size of pulley, inches	Includes	Cost ¹
Crusher.....	15	8 by 6-3/4	Line starter, \$28.56; safety switch, \$11.05.	\$181.57
Rolls.....	10	6 by 3-1/2	Line starter, \$28.56; safety switch, \$6.50.	150.98
Conveyors (2)	5		2 line starters at \$28.56 each; 2 safety switches at \$3.90 each.	513.48
Feeder.....	1	3 by 3	Line starter, \$15.96; safety switch, \$3.90.	59.34
Samplers (2)...	1	3 by 3	2 line starters at \$15.96 each; 2 safety switches at \$3.90 each.	118.68
Grinder.....	3	4 by 3-1/2	Line starter, \$15.96; safety switch, \$3.90.	80.34
Pulverizer.....	2	4 by 3-1/2	Line starter, \$15.96; safety switch, \$3.90.	75.30
Air compres- sor.	1	3 by 3	Line starter, \$15.96; safety switch, \$3.90.	59.34
Total.....	44			1,239.03

¹As of August 15, 1935, based on discounts applicable to the Federal Government.

The first cost of driving the plant by electric power with line shafts or by individual motors is about the same.

Although not standard practice, the conveyor to the storage bin could be operated from the lower end from the line shaft. Should this be done, a saving of \$257 for the geared motor could be made with a line-shaft drive.

Should electric power not be available for purchase it could be generated on the ground, or the plant could be driven directly by Diesel or gasoline engines. The layout of the sampling works, as shown in figure 1, is such that one prime motor could not run the entire plant by belts without a long belt transmission line from the main building to the crusher. Apparently there would be a choice between one Diesel electric plant or two gasoline engines.

Diesel engines have the advantage of producing power at lower cost than gasoline engines, but the first cost is considerably greater per horsepower. For a plant with a long life ahead of it, a Diesel plant would probably be more economical than gasoline engines.

High-speed Diesel plants cost considerably less than low-speed machines but produce more energy per pound of fuel. Figures supplied by Fairbanks, Morse & Co. for a 60-hp. Diesel plant show that the fuel consumption of a low-speed plant would be 0.48 pound of fuel oil per brake horsepower-hour at full load as against 0.38 pound for a high-speed plant.

Fuel consumption of gasoline engines is 0.67 pound per brake horsepower-hour. Moreover, gasoline engines require 25 percent more lubricating oil than Diesels.

If a Diesel-electric drive were used, a 25-percent loss of power in the generator and motors should be considered. The total motor horsepower, as shown by table 2, is 44; the

operating load would be about 35 horsepower. Table 3 contains quoted costs and other data for engines that could be used in the sampling plants.

If Diesel-electric power were decided upon, the best of the engines quoted would appear to be Model 36 with a generator, which costs \$3,633 delivered at the nearest main-line railroad point. A similar assembly with a lower-speed engine, shown in the table, would cost \$4,570.

TABLE 3.- Data on Diesel and gasoline engines suitable for sampling plants

Kind	Model	Horsepower		Number of cylinders	R.p.m.	Weight, pounds	Cost,	Freight	Cost delivered
		Maximum	Sustained				f.o.b. factory	at \$4.50 a hundred pounds	
Diesel.....	a/36	60	48	6	1,200	3,200	\$2,340	\$144	\$2,484
Do.	a/, b/36	60	48	6	1,200	6,380	3,346	287	3,633
Do.	B-2	75	40	2	514				3,230
Do.	D7700	63	48	4	600	6,220	2,487	280	2,767
Do.	c/D7700	63	48	4	600	9,200	4,156	414	4,570
Gasoline..	d/Ford			4	625				205
Do.	d/Chrysler					1,240	562	56	618
Do.	1XA	e/36.5	25.5	4	1,800		302		
Do.	f/FM3	22.3	17.8		1,800	585	370	26	396
Do.	f/FM4	28.3	22.8		1,800	825	430	37	467
Do.	f/FM5	37.8	33.6		1,800	1,000	475	45	520
Do.	f/G4A	g/29.2	24.8		1,000	2,265	h/825	102	927
Do.	f/, i/G4A	g/29.2	24.8		1,000	2,265	h/975	102	1,077

a/ Complete with radiator and starting battery.

b/ With 39.6-kw., 3-phase, 60-cycle, 240-volt alternator and excitor.

c/ With generator.

d/ Complete, but without mounting.

e/ At 2,600 r.p.m.

f/ Complete.

g/ At 1,200 r.p.m.

h/ Electric starting unit \$122 extra.

i/ Converted to burn tops or Diesel oil.

Should two gasoline engines be used, FM5 at \$520 for the main plant and FM3 at \$396 for the crusher would appear to serve the purpose. The total cost would be \$916.

Two 4-cylinder Ford engines apparently would supply sufficient power at lower first cost, but this equipment may not now be obtainable.

As shown by table 3, Model G4A gasoline engine can be converted to burn tops or fuel oil at an additional cost of \$150, or \$1,077 for the engine. Two of these engines would cost \$2,154.

Assuming a sustained load of 35 horsepower, 25-percent loss in the generator and motors, and 15 horsepower-hours per gallon of Diesel oil (or 0.48 pound of fuel per hp. hr.), the consumption of fuel oil would be 3 gallons per hour for the Diesel-electric plant. Assuming 9 horsepower-hours per gallon of gasoline (or 0.67 pound of fuel per hp. hr.) for the two gasoline engines, the consumption of fuel would be 3.9 gallons per hour.

The fuel cost for the Diesel-electric plant would be three times \$0.075 (average cost in western mining camps in 1935), or \$0.23 per hour, or \$1.80 per 8-hour shift. The gasoline

would cost 3.9 times \$0.13 (third-grade, exclusive of State tax), or \$0.51 per hour, or \$4.08 per 8-hour shift. A saving in fuel of \$2.28 per day, or \$0.07 per ton, would be indicated by using a Diesel plant. As the Diesel fuel could not be used in automobiles, the saving probably would be greater. The difference in fuel for 300 days' operation would be \$684.00.

Assuming 11 horsepower-hours per gallon of fuel oil for the converted gasoline engines, the daily cost would be \$1.91. Apparently two Model G4A's, or similar engines, would be the most economical to use, considering the first cost and power loss with the Diesel-electric set-up.

As running the plant only one shift per day was contemplated, lights would not be required in the plant. Should a night shift be worked, a 5-horsepower generator would have to be added to the set-up for gasoline-engine drive and consideration given to this additional power load.

A charge for labor must be made against gasoline or Diesel power; in this case, however, another operator would not be required. The chief operator could look after the power plant along with his other duties.

ASSAY OFFICE

As it would be expected that settlements for shipments would be made on the assays made at the sampling works, an adequate assay office would be required. Provision was made for both fire assaying and wet analytical work.

A plan of the proposed assay office is shown in figure 12. The building was to be of frame construction with a corrugated sheet-iron roof. The bill of material for the assay office is shown in table 4. The equipment and supplies for the assay office are shown in table 5. This is compiled mainly from a list suggested by the Denver Fire Clay Co. Prices are from the 1934 catalog, except balances, which are 1935 quotations. Table 6 is a summary of tables 4 and 5.

TABLE 4.- Bill of material for assay office

Quantity	Item	Unit price	Amount
<u>Construction materials</u>			
84.....linear feet	4- by 6-inch mud sill.....	\$40.....per M	\$6.72
8.....do.....	12- by 12-inch timber for balance support.....	40.....do.....	3.84
304.....do.....	2- by 6-inch floor joists.....	30.....do.....	9.12
304.....do.....	2- by 6-inch ceiling joists.....	30.....do.....	9.12
488.....do.....	2- by 6-inch rafters.....	30.....do.....	14.64
32.....do.....	4- by 4-inch corner posts.....	40.....do.....	1.72
944.....do.....	2- by 4-inch studs and girts.....	30.....do.....	18.90
416.....board feet	1- by 10-inch subfloor.....	27.50.....do.....	11.44
616.....do.....	1- by 10-inch roof sheathing.....	27.50.....do.....	16.94
188.....do.....	1- by 6- 8- 10-inch trim.....	40.....do.....	7.52
676.....do.....	1- by 8-inch shiplap.....	35.....do.....	23.66
460.....do.....	1- by 6-inch tongue-and-groove flooring.....	45.....do.....	20.70
100.....do.....	1-inch dressed lumber for shelves, etc.	45.....do.....	4.50
260.....do.....	1- by 4- 6-inch lumber for window and door frames. ¹	45.....do.....	11.70
412.....linear feet	1- by 4-inch scantling.....	35.....do.....	4.83

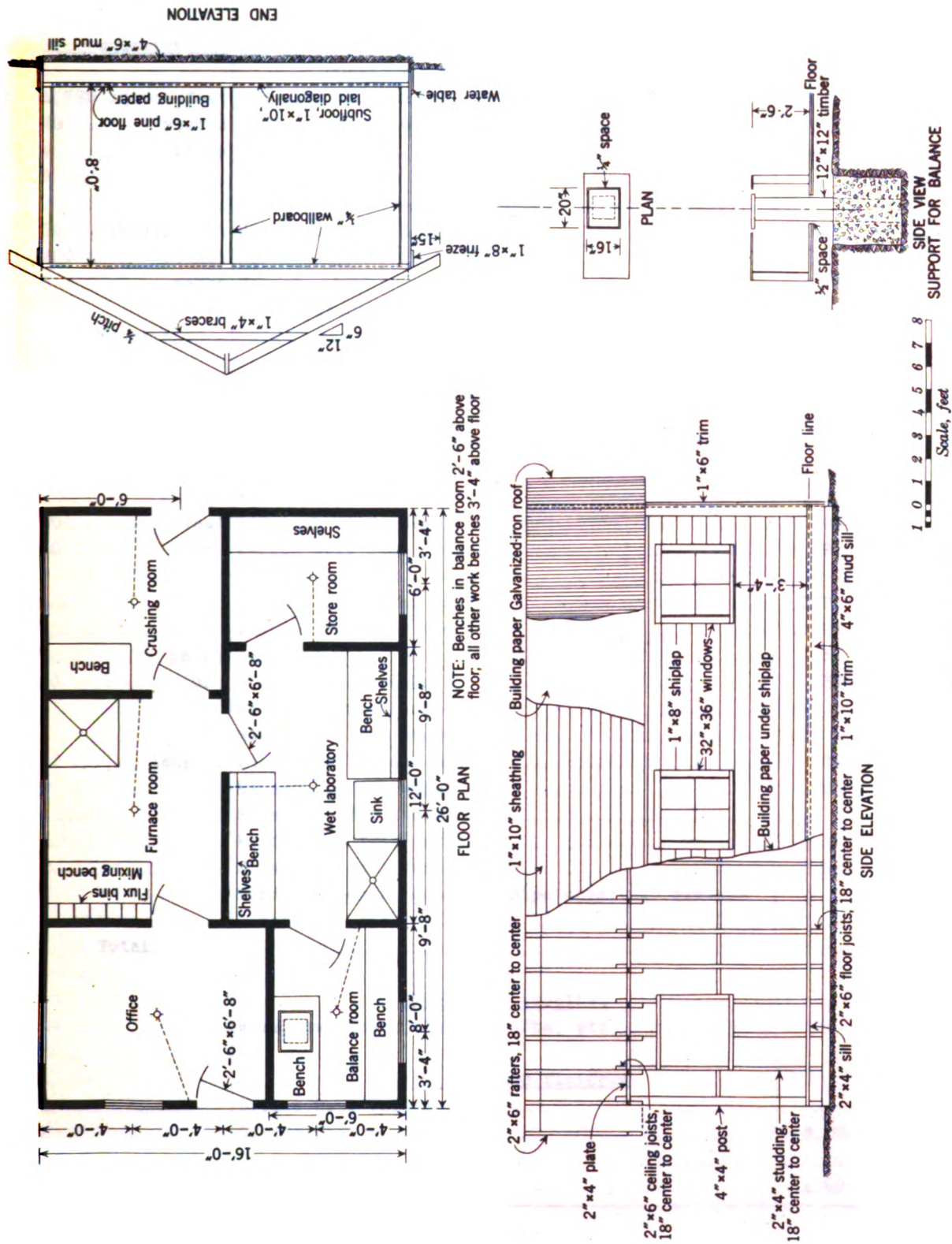


Figure 12.—Assay office.

TABLE 4.- Bill of material for assay office - Continued

Quantity	Item	Unit price	Amount
<u>Construction materials - Continued</u>			
1,780 square feet	1/4-inch wall board.....	\$50..... per M	\$89.00
48..... sheets	G. I. roofing, 6-foot lengths.....	.72 per sheet	34.56
4..... rolls	Building paper.....	1.35..per roll	5.40
8.....	Windows, 32- by 36-inch.....	4.00..... each	32.00
7.....	Doors, 2-foot 6-inch by 6-foot 8-inch (5-panel)....	4.14..... do....	28.98
30..... linear feet	Metal ridge roll.....	.10...per foot	3.00
200..... pounds	Nails.....	.06 per pound	12.00
3..... sacks	Cement.....	1.00...per sack	3.00
	Miscellaneous (molding, water table, etc.).....		<u>20.00</u>
Total.....			393.29
<u>Hardware</u>			
2..... gallons	House paint.....	3.45..... gallon	6.90
1.....	20- by 24-inch acid-resisting sink, flat rim.....	7.00..... each	7.00
1.....	Acid-resisting trap to wall.....	9.00..... do....	9.00
1.....	Faucet, 1/2-inch.....	1.15..... do....	1.15
50..... feet	1/2-inch water pipe ²	.06...per foot	3.00
40..... do..	2-inch soil pipe.....	.95 per 5 ft.	7.60
	Pipe fittings.....		4.50
2.....	Outside locks for doors.....	2.50..... each	5.00
5.....	Inside locks for doors.....	1.25..... do....	6.25
7..... pairs	Door butts.....	.35..... pair	2.45
20..... do..	Steel shelf brackets.....	.30..... do....	3.00
1.....	Heating stove (laundry).....		14.00
1.....	Metal base for stove.....		1.00
12..... lengths	Stovepipe, 5-inch diameter.....	.15..... length	1.80
2.....	Elbows for stovepipe.....	.25..... each	.50
1.....	Fume hood for laboratory.....		3.50
1.....	Hood for muffle furnace.....		3.50
2.....	Stovepipe roof vents.....	1.50..... each	3.00
	Window catches, asbestos pipe covering, miscellaneous, etc.		<u>15.00</u>
Total.....			98.15
<u>Electrical supplies</u>			
	Wire, switches, cleats, bulbs, etc.		20.00
<u>Furniture and fixtures</u>			
1.....	Office desk (plain top).....		25.00
2.....	Office chairs.....	3.00..... each	6.00
1.....	Desk chair.....		5.00
4.....	Window shades.....	1.00..... each	4.00

¹Door and window frames to be made on the job.²Laboratory sink to discharge into outside toilet. Toilet to be constructed of left-over material from assay office.

TABLE 4.- Bill of material for assay office - Continued

Quantity	Item	Unit price	Amount
<u>Furniture and fixtures - Continued</u>			
1	Broom		\$ 1.00
1	High stool for laboratory		1.50
1	Low stool for balance room		1.50
Total			44.00
Total materials			555.44
Labor for erection			300.00
Total cost of assay office			855.44

TABLE 5.- Equipment and supplies for assay office**FIRE ASSAYING**

Balances and weights:

DFC No. 384 Button, Heusser, sensitivity 1/500 mg	\$250.00
Braun 12127 pulp, sensitivity 1/2 mg	50.00
DFC No. 462 scoop and platform, 25-pound, 240-pound platform	20.00
DFC No. 442 moisture balance	30.00
DFC No. 514 weights for Button balance	25.00
DFC No. 544 weights for assay-ton balance	6.50
1 rubber-sheeting scale cover	2.20
	<u>383.70</u>

Furnace:

Braun No. 31050 furnace, type 40, gasoline	100.50
--	--------

Miscellaneous equipment and supplies:

Buckboard, 20 by 24 inches, and muller	18.00
Buckboard brush	2.25
Iron cupel tray	.90
1 dozen parting flasks	1.94
1 pair forceps	1.10
2 pairs forceps, slag, 6-inch	.60
1 pair asbestos mittens, 14 inch	2.50
1 slagging hammer, 15 ounce	2.00
1 slagging hammer, 9 ounce	1.60
1 box labels	.10
1 alcohol lamp, 4 ounce	.40
1 Dangler lamp	12.00
1 lead measure	.25
1 4-1/2 mallet	1.50
1 magnifier, 3 glass	1.75
1 magnet, 6 inch	.45
1 pouring mold	1.00
1 pair button pliers	1.25
1 blowpipe	.75
1/2 dozen bottles, 8 ounce	2.13
3 brushes	1.55

TABLE 5.- Equipment and supplies for assay office - Continued

FIRE ASSAYING - Continued

Miscellaneous equipment and supplies (Continued):

1 button tray.....	\$1.00
1 dozen charcoal sticks.....	.55
12 crucibles, 00 size.....	1.44
2 cartons, 96 each clay crucibles, 20 gram.....	10.37
12 roasting dishes, 5 inch.....	1.58
1 yard rubber sheeting.....	1.00
1 sampler, complete, 6 by 6 inch.....	3.50
12 sample pans, 6 inch.....	.76
150 scorifiers, 2-1/2 inch.....	4.14
1 set sieves, 8 inch, 20, 35, 48, 65, 100 mesh, with pan and cover.....	12.45
1 steel spatula, 6 inch.....	.50
1 pair tongs, 9 inch.....	.72
1 pair tongs, 30 inch.....	2.25
1 pair tongs, crucible.....	1.50
1 pair tongs, cupel.....	1.50
1 muffle scraper.....	.85
12 annealing cups.....	1.35
1 annealing tray.....	1.35
1 anvil, 6 by 6 inch.....	4.00
1 anvil, 2-1/2 by 2-1/2 inch.....	2.00
1/2 sheet, asbestos mill board, each 20 by 40 by 1/2 inch.....	1.75
2 extra muffles.....	4.30
125 mailing envelopes, 6 ounce.....	<u>1.24</u>
	114.12

Reagents, initial stock:

5 pounds test lead, C.P.	.75
200 cupels, 1-1/4 inch.....	4.30
25 pounds litharge C.P.	3.75
10 pounds borax glass.....	1.80
1 pound lead foil C.P.	.40
1 ounce silver foil C.P.	1.50
1 bottle acid nitric, C.P., 7 pound.....	<u>1.89</u>
	14.39

WET ASSAYING

Analytical balance and weights:

1 DFC analytical balance, 200 grams.....	70.00
1 set analytical weights, 50 grams down.....	15.00
1 scale cover.....	<u>2.20</u>
	87.20

Miscellaneous equipment and supplies:

1 sheet 1/4-inch asbestos mill board, 15 1/2 pound.....	1.40
2 yards asbestos paper for hot plates, 1-1/2 pounds to yard.....	.45
12 pyrex beakers, lipped, 50 cm ³	2.04

TABLE 5.- Equipment and supplies for assay office - ContinuedWET ASSAYING - Continued

Miscellaneous equipment and supplies (Continued):

13 pyrex beakers, lipped, 150 cm ³	\$2.47
48 pyrex beakers, lipped, 250 cm ³	9.60
24 pyrex beakers, lipped, 400 cm ³	6.24
6 pyrex beakers, lipped, 1,000 cm ³	3.00
5 reagent bottles, 2 HNO ₃ , 1 HCl, 1 H ₂ SO ₄ , 1 NH ₃	3.29
5 caps for above.....	.98
12 reagent bottles, 8 ounce, for reagents that follow.....	6.00
12 reagent bottle caps for above.....	2.30
1 pyrex wash bottle, complete, 500 cm ³	.75
2 pyrex wash bottles, complete, 1,000 cm ³	2.00
6 CH pencil brushes, 1/2 inch.....	1.50
2 burettes, 50 cc, G.8.....	2.30
1 burette, dispensing, 500 cc.....	3.50
6 No. 3 casseroles.....	3.60
6 No. 3A casseroles.....	4.50
4 clamps, Mohrs, 2-3/4 inch.....	.60
1 12-hole color-test plate, 110 mm.....	.70
1 gross assorted corks.....	1.10
1 cork borer, 6 p.c.	.80
24 porcelain crucibles, no. 0.....	3.60
1 graduated cylinder, 100 cm ³	.40
2 graduated cylinders, 1,000 cm ³	2.40
500 filters, 11 cm.....	2.45
1 filter pump.....	2.25
1 first-aid outfit.....	15.00
12 pyrex Erlm flasks, 300 cm ³	2.28
1 filter flask, 500 cm ³	1.45
1 forceps.....	.60
1 funnel, 8-3/4 inch.....	1.00
100 white filters to fit 18 inch.....	1.55
2 pounds glass tubing, 7 mm.....	1.10
1 pound glass rod for stirrers.....	.60
1 asbestos gloves, no. 14.....	2.50
2 Vanning plaques.....	3.50
1 box labels no. 201.....	.10
12 funnels, 75 mm.....	3.67
250 sample envelopes, 4 ounce.....	2.10
6 pencils, blue, for glass.....	.90
3 pipettes, volumetric, 10.....	.75
2 rubber stirrers.....	.50
1 pound assorted rubber stoppers.....	.90
2 yards black sheeting for mixing.....	2.00
12 feet tubing, MW PG, 3/16 inch.....	1.08
12 feet tubing, MW PG, 1/4 inch.....	1.51
24 sample pans, 5-1/4 inch.....	1.30
18 sample pans, 10 inch.....	2.92

TABLE 5.- Equipment and supplies for assay office - Continued

WET ASSAYING - Continued

Miscellaneous equipment and supplies (Continued):

1 spatula, no. 5.....	\$.80
1 spatula, no. 3.....	.35
1 spatula.....	.50
1 support for 2 burettes.....	1.95
1 support, 4 ring.....	2.00
2 supports, 6 funnels.....	7.00
12 assorted test tubes, pyrex.....	1.10
2 tongs, beaker.....	.80
1 each, triangles, nos. 1, 2, and 3, lot.....	.85
6 dozen watch glasses to fit beakers, lot.....	2.50
1 H ₂ S generator.....	.55
1 shears, 5 inch.....	1.35
Gas hot plates.....	18.00
1 Bunsen burner.....	.40
Water still.....	16.00
Compressed-gas installation.....	60.00
	<u>231.68</u>

Chemicals, initial stock:

2 5-pound bottles acetic acid, 99-1/2 percent.....	2.00
1 barrel 4 9-pound bottles CP sulphuric acid.....	6.00
1 barrel 4 6-pound bottles CP hydrochloric acid.....	4.50
1 barrel 4 4-1/2-pound bottles CP ammonia.....	4.50
10 pounds ammonium acetate CP.....	7.30
3 pounds ammonium chloride USP.....	1.29
1 pound potassium permanganate CP.....	.87
1 pound ammonium molybdate USP.....	1.75
1 pound sodium cyanide.....	.50
1 pound sodium hyposulphite CP.....	.53
1/2 pound acid oxalic CP.....	.72
1/4 pound acid tartaric.....	.43
1 gallon denatured alcohol and can.....	1.00
1 square foot aluminum, 1/16 inch.....	1.00
1/4 pound ammonium carbonate CP.....	.33
1 pound ammonium persulphate CP.....	.91
1 pound barium chloride CP.....	.65
1/4 pound copper foil CP 0.008.....	.35
1/4 pound copper sulphate CP, crystal.....	.34
1/4 pound ferrous ammonium sulphate CP.....	.33
1/4 pound ferrous chloride CP.....	.52
1/4 pound ferrous sulphate CP.....	.32
1/4 pound lead acetate CP.....	.33
1 ounce lead sulphate CP.....	.25
5,914 litmus paper, 13-books, 6 red, 7 blue.....	.65
1 box lubriscal for stopcocks.....	.40
1 ounce methyl orange.....	.54

TABLE 5.- Equipment and supplies for assay office - Continued

WET ASSAYING - Continued

Chemicals, initial stock (Continued):

1 ounce phenolphthalein.....	\$.21
1/4 pound potassium ferricyanide CP.....	.52
1/4 pound potassium iodide CP.....	1.00
1 barrel 5 7-pound bottles nitric acid CP.....	8.00
1 pound mercury.....	1.60
1 ounce silver nitrate CP.....	.55
1/4 pound sodium bicarbonate CP.....	.31
1 pound potassium chlorate CP.....	.61
1 pound sodium hydroxide CP, sticks.....	.71
1 ounce soluble starch.....	.25
1 pound zinc oxide CP, dry.....	.74
1 ounce uranium acetate.....	.62
1 ounce tannic acid CP, fluffy.....	.31
1 ounce iron wire CP, for standards.....	.35
5 pounds hydrogen peroxide USP.....	1.25
10 pounds silica powder.....	.60
10 pounds potassium carbonate powder for assaying calcines.....	1.70
	<u>57.64</u>

ORE TESTING

Laboratory flotation machine.....	150.00
Bottle rolls (estimate).....	<u>50.00</u>
	200.00

Total cost of assay equipment and supplies..... 1,189.23

TABLE 6.- Summary of costs of building, equipment, and supplies for assay office

Building:		
Materials.....	\$555.44	
Labor.....	<u>300.00</u>	\$ 855.44
Fire assaying:		
Balances and weights.....	383.70	
Furnace, gasoline.....	100.50	
Miscellaneous supplies and equipment..	114.12	
Initial stock reagents.....	<u>14.39</u>	612.71
Wet assaying:		
Analytical balance and weights.....	87.20	
Miscellaneous supplies and equipment..	231.68	
Initial stock chemicals.....	<u>57.64</u>	376.52
Ore testing:		
Laboratory flotation machine.....	150.00	
Bottle rolls (estimate).....	<u>50.00</u>	200.00
		<u>\$1,189.23</u>
Grand total.....		<u>\$2,044.67</u>

GENERAL SPECIFICATIONS

Timber

All timber used in the construction of bins and other structures for the sampling works shall be of No. 1 common timber, except where otherwise noted. The No. 1 common rough timber shall be free from loose and unsound knots and from large knots so located as to impair the strength of any member materially. Only the allowable commercial variation below the nominal size in cutting shall be allowed. The acceptance of such timber, as to the quality and size, will be subject to the approval of the engineer in charge.

The following allowable unit values for the timber have been assumed in the calculations for the design of the structures:

	<u>Pounds per sq. in.</u>
Extreme fiber stress in bending.....	800
Compression perpendicular to the grain	200

This low fiber stress has been used because local timber that might be used in the erection of plants in some portions of the United States is of very poor grade. Some of the plants, however, would be located in territory where douglas fir or longleaf pine would be available. In such cases the width of the stringers of the ramp and the tension members in the bins can be reduced in proportion to the increase in fiber stress allowable on the higher grade timber. For example, two 12- by 12-inch stringers are shown (fig. 3) under each wheel in the ramp. If shortleaf pine should be available, with a fiber stress of 1,100 pounds, the width of the above members could be reduced 37 1/2 percent; this would indicate a width under 8 inches. In other words, if shortleaf pine should be available, the stringers in the ramp could consist of two 8 by 12's placed on edge instead of two 12 by 12's under each wheel. Permission for the reduction in size of the timber should be obtained from the engineer in charge before such reductions are made.

Concrete

The materials for all concrete shall be first class in every respect and subject to the approval of the engineer in charge. The sand shall be clean and sharp, with no more than 1/2 percent earth or alluvial matter. The gravel or crushed rock used in the cement shall pass through a 2-inch opening. No large pieces of rock or "plums" will be allowed in the concrete construction. The cement used shall be of an approved standard brand in commercial use in the locality in which the plant is being built and shall, of course, be subject to the engineer's approval and test, if required.

All concrete used in the construction of these structures for floors, ordinary foundations, or footings shall be in the proportions of 1 part cement, 3 parts sand, and 5 parts gravel by volume. Concrete that will be subject to tension stresses, such as in the crusher reinforced foundation, is to be of a 1:2:4 mixture. All floors in the sampling plant are to be poured 6 inches thick of a 1:3:5 mixture; the top of this concrete is to be 1 inch under grade. A finish coat on the floor is to consist of 1 part cement and 3 parts of sand, and the surface is to be well-troweled with a steel trowel so as to be as smooth as possible. The materials used and the workmanship on this floor are to be subject to the acceptance of the engineer in charge.

Corrugated Roofing and Siding

Buildings shall be covered as shown on the drawings, with galvanized corrugated iron having standard 2-1/2-inch corrugations. Roofs shall be of no. 24 gage, and all siding shall be of not less than no. 26-gage iron. Both roofs and sides shall be laid with a minimum of 1-1/2 corrugations as side lap and a minimum of 6 inches on the end lap of sheets. The side lap shall be so placed that any leakage will be protected by two valleys or corrugations.

Conveyors

Conveyor materials, such as troughing and return idlers, gears, head and tail pulleys, take-ups, etc., may be furnished by any of the well-known manufacturers, subject to the approval of the engineer in charge. Conveyor idlers shall be of the 3-roller type and spaced not over 5 feet apart; return idlers may be placed as much as 10 feet apart. Side idlers must be placed as shown in the drawings. Each conveyor must be equipped with a hold-back or nonreturn stop, so that in case the conveyor drive fails, the conveyor belt will not run in the reverse direction. The take-ups on the tail pulleys shall be of standard design, with not less than 9 inches of travel. The head pulleys shall be as specified in the drawings and be rubber-covered. The conveyor belt shall be not less than 4-ply, 28-ounce duck, with 1/8-inch top, and 1/32-inch bottom rubber cover. All troughing and return idlers, head and tail pulleys, and countershafts shall have their bearings provided with suitable grease cups.

LISTS OF MATERIALS AND COSTS

The estimates given herein are for a plant to be driven by purchased electric power. Line shafts and belt drives would be used in the main sampling mill, which would be run by a 40-horsepower motor. A 15-horsepower motor would be used on the crusher and a 5-horsepower geared motor on the conveyor to the storage bins.

The following tabulations give the materials and equipment required and the estimated costs for each part of the sampling works. Quotations for equipment are of autumn of 1935, as applicable to Government purchases.

TABLE 7.- Timber list for approaches to receiving bins (fig. 3)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
16.....	10 by 12	20	Sills.....	3,200
16.....	10 by 12	18	Caps.....	2,880
16.....	10 by 12	12	Corbels.....	1,920
3.....	10 by 10	14	Posts.....	350
9.....	10 by 10	12	do.	900
6.....	10 by 10	20	do.	1,000
6.....	10 by 10	12	do.	600
4.....	8 by 10	14	Inclined posts.....	373
6.....	8 by 10	12	do.	480
2.....	8 by 10	16	do.	213
6.....	8 by 10	14	do.	560
2.....	3 by 12	22	Sway braces No. 10.....	132
14.....	3 by 12	20	Sway braces, Nos. 2, 3, 4, 11, 12, 13.....	840
16.....	3 by 12	18	Sway braces, Nos. 5, 6, 7, 8, 9, 14, 15, 16.....	864
8.....	3 by 12	20	Sway braces.....	480
8.....	3 by 12	18	do.	432
16.....	3 by 12	16	do.	768
64.....	12 by 12	12	Stringers.....	9,216
32.....	6 by 12	12	Stringers, outside.....	2,304
8.....	6 by 10	12	Corbels.....	480
32.....	2 by 6	12	Handrail.....	384
48.....	2 by 6	12	Handrail supports.....	576
184.....	3 by 12	14	Roadway deck.....	7,728
Total feet, board measure.....				36,680

TABLE 8.- List of hardware for approaches to receiving bins (fig. 3)

200	Feet	7/8-inch round mild steel for drift bolts for bents.
140	Only	3/4-inch bolts, 26 inches long, for bolting stringers to cords, complete with square nuts and 4-inch thread each end.
150	do.	3/4-inch O. G. washers.

TABLE 9.- Cost of approaches to receiving bins (fig. 3)

Fill, 486 cubic yards at \$1 per cubic yard.....	\$ 486.00
Excavation.....	50.00
Concrete piers, 10 cubic yards at \$12 per cubic yard.....	120.00
Timber, including construction, 37,000 board feet at \$50 per thousand (table 7).....	1,850.00
Hardware (table 8).....	100.00
Total.....	2,606.00

TABLE 10.- Timber list for receiving bins (fig. 4)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
1.....	8 by 10	22	Front sill.....	147
8.....	8 by 8	14	Sills.....	597
8.....	8 by 8	14	Posts.....	597
4.....	8 by 8	10	do.	213
8.....	8 by 8	12	Sway braces.....	512
8.....	6 by 10	18	Bottom beams.....	720
2.....	8 by 8	22	Bottom supports.....	234
2.....	8 by 8	24	Front ties.....	256
2.....	8 by 8	16	End ties.....	171
4.....	8 by 8	20	Caps.....	427
6.....	8 by 8	22	Runway beams.....	704
4.....	6 by 8	14	Guards on top.....	224
3.....	2 by 6	16	Handrails.....	48
2.....	8 by 8	16	End verticals.....	171
40.....	2 by 12	22	Bin lining.....	1,760
48.....	2 by 12	12	do.	1,152
Total feet, board measure..				7,933

TABLE 11.- List of hardware for receiving bins (fig. 4)

2	Only	1/4-inch mild steel plates, 2 feet 6 inches wide by 22 feet long.
24	Pieces	40-pound T rail, 13 feet long.
24	Only	45° O. G. washers for 1-inch bolts.
100	Feet	1-inch round mild steel rods for tie rods and bolts.
12	Only	O. G. washers for 1-inch bolts.
24	do.	3/4- by 14-inch bolts.
24	do.	O. G. washers for 3/4-inch bolts.
		Necessary square nuts for above.
3	do.	24-inch wide Arc gates. Chutes to be of timber lined with 1/8-inch steel plate on bottom and sides.
1	do.	Hopper, complete.....
		<u>Bin lining:</u>
3	Pieces	3/16-inch mild steel plate, 6 feet wide by 17 feet long.
3	do.	3/16-inch mild steel plate, 6 feet wide by 13 feet long.
6	do.	3/16-inch mild steel plate, 6 feet wide by 15 feet long.

TABLE 12.- Cost of receiving bins (fig. 4)

Excavation, 2 cubic yards at \$1 per cubic yard.....	\$ 2.00
12 concrete piers, 5.35 cubic yards at \$12 per cubic yard.....	64.00
Timber, including construction, 8,000 board feet at \$50 per thousand (table 10).....	400.00
Bolts, rods, and washers.....	25.00
2 only 1/4-inch M. S. plates, 2 feet 6 inches wide by 22 feet long, 1,200 pounds at \$0.05.....	60.00
Laying plates.....	10.00
24 pieces 40-pound T rail, 13 feet long, 4,170 pounds at \$0.04.....	167.00
Assembly.....	20.00
24-inch arc gates, 3 at \$35 each.....	105.00
Erection.....	15.00
Front and bottom bin lining, 3/16-inch M. S. plate, 2,265 pounds at \$0.05.....	113.00
Cutting and erection.....	50.00
Total.....	1,031.00

TABLE 13.- List of hardware for crusher pit (fig. 5)

5	Only	5/8-inch reinforcing bars, 7 feet long.
13	do.	5/8-inch reinforcing bars, 8 feet long.
4	Pieces	1-1/2-inch pipe, 10 inches long, for hopper under crusher.
1	Only	Hopper, complete, as shown in figure 5.

TABLE 14.- Equipment for crushing pit (fig. 6)

1	Only	9- by 16-inch Telsmith Wheeling jaw crusher. Drive pulley 33 by 8-1/2 inches.
4	do.	Anchor bolts, 1 by 18 inches.
4	do.	W. I. pipe sleeves, 1-1/2 by 10 inches, in foundation.
35	Feet	Transmission belt, 6 inches wide, 4-ply, of medium quality.

TABLE 15.- Cost of crusher pit (fig. 5) and equipment (fig. 6)

Excavation, 120 cubic yards at \$1 per cubic yard.....	\$ 120.00
Concrete, 40 cubic yards at \$12 per cubic yard.....	480.00
Reinforcing bars, anchor bolts, etc. (table 13).....	35.00
Steel hopper under crusher (table 13).....	25.00
Telsmith Wheeling jaw crusher, 9 by 16 inches, weight 5,490 pounds.....	1,225.00
Freight.....	70.00
Erection.....	75.00
15-hp. motor, 1,750-r.p.m., complete with switch and starter.....	182.00
Anchor bolts, belt drive, and erection.....	40.00
Total.....	2,252.00

TABLE 16.- Timber list for conveyor gallery to sampling mill (fig. 6)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
2	6 by 10	10	Stringers	100
8	6 by 10	16	do.	640
12	2 by 6	14	Floor joists	168
23	2 by 4	14	Posts	215
4	2 by 4	16	Sway braces	43
18	2 by 4	14	Caps	168
30	2 by 4	18	Trusses	360
40	2 by 4	14	Purlins	373
20	2 by 4	14	Girts	186
3	4 by 6	20	Floor joists	120
63	2 by 12	14	Floor	1,764
1	4 by 8	10	Hoist support	27
3	4 by 4	16	Posts	64
2	4 by 6	10	Hoist support	40
6	2 by 4	12	Stair handrail	48
1	6 by 8	12	Stair support	48
1	6 by 6	12	Bent 2	36
1	6 by 6	16	do.	48
1	2 by 8	20	do.	27
14	4 by 6	20	Conveyor	560
14	2 by 4	20	Bent 3	187
1	6 by 6	16	do.	48
1	6 by 6	20	do.	60
2	2 by 8	14	do.	37
1	6 by 6	14	Bent 4	42
1	6 by 6	10	do.	30
2	6 by 6	16	do.	96
2	2 by 10	20	do.	67
2	4 by 6	16	do.	64
8	2 by 12	16	Stairs	256
Total feet, board measure				5,922

TABLE 17.- List of hardware for conveyor gallery to sampling mill

16	Only	Sliding sash with 4 10- by 12-inch lights without frames.
1	do.	No. 2 H door.
2	do.	No. 7 H doors.
1	do.	3 foot 6 inch by 6 foot 2 inch door.
6	Pieces	1-inch pipe, 12 inches long, for foundation dowels.
126	do.	No. 24-gage galvanized corrugated iron, 8 feet long.
120	do.	No. 24-gage galvanized corrugated iron, 5 feet long.
8	do.	No. 24-gage galvanized corrugated iron, 10 feet long.
130	Feet	Galvanized-iron ridge roll.

TABLE 18.- Equipment for conveyor to sampling mill (fig. 6)

1	Only	Conveyor, 16 inches wide, 121 feet long, to consist of:
1	do.	18- by 18- by 1-15/16-inch bore, rubber-covered head pulley and shaft with automatic holdback.
1	do.	23.89 P. D. gear, 1-inch pitch, 2-1/2-inch face, 1-15/16-inch bore.
2	do.	1-15/16-inch common flat split boxes.
2	do.	1-15/16-inch split set collars.
1	do.	5.12 P. D. pinion, 2-3/4-inch face, 1-inch pitch, 1-7/16-inch bore.
1	do.	30- by 4- by 1-7/16-inch bore C. F. split steel drive pulley.
2	do.	1-7/16-inch common flat split boxes.
2	do.	1-7/16-inch split set collars.
1	do.	18- by 18- by 1-15/16-inch bore tail pulley complete with shaft.
2	do.	1-15/16-inch split set collars.
1	Pair	1-15/16-inch take ups, 9-inch travel.
25	Only	16-inch, 3-roll troughing idlers, complete with grease cups.
12	do.	16-inch return idlers, complete with grease cups.
247	Feet	16-inch wide, 4-ply, 28-ounce duck, 1/8-inch rubber top cover, 1/32-inch bottom cover conveyor belt.

TABLE 19.- Cost of conveyor and conveyor gallery to sampling mill (fig. 6)

Excavation.....	\$ 5.00
Concrete, 1/2 cubic yard at \$12 per cubic yard.....	6.00
Timber, including construction, 6,000 board feet at \$50 per thousand (table 16).....	300.00
Corrugated iron, 33 squares at \$5.50 each.....	181.00
Laying, \$1.75 per square.....	58.00
Sashes, 16 at \$4 each, in place.....	64.00
Doors, 2, with hardware, in place.....	30.00
16-inch conveyor (table 18).....	875.00
Erection.....	75.00
5-hp. motor, geared, complete with switch and starter.....	257.00
Erection and wiring.....	20.00
Total.....	1,871.00

TABLE 20.- Timber list for sampling mill (fig. 7)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
3	8 by 8	16	Posts	256
2	6 by 8	16	do.	128
2	8 by 8	22	Caps	235
2	8 by 10	22	do.	293
2	6 by 8	22	Beams	176
2	10 by 12	12	do.	240
12	2 by 10	16	Joists	320
8	2 by 10	22	Caps	293
80	2 by 6	12	Studs and girts	960
14	2 by 6	14	Cable ends	196
4	4 by 6	14	Trusses	112
8	2 by 10	20	do.	267
18	2 by 6	16	Purlins	288
40	2 by 12	12	Floor	960
1	3 by 8	20	Knees	40
1	4 by 6	20	do.	40
Total feet, board measure				4,804

TABLE 21.- Sampling equipment for sampling mill (fig. 8)

2	Only	Vezin samplers, no. 1 size for 1-inch feed, complete with drive pulley and proper lag screws for mounting with 26- by 3-1/2-inch T. & L. drive pulleys.
1	do.	18-inch wide by 24-inch high ore-bin gate, rack and pinion type, complete with necessary lag screws.
1	do.	14-inch belt feeder for rolls, complete with gear reduction and drive pulley.
1	Set	18- by 10-inch "Economics" rolls.
1	Only	Braun pulverizer.
1	do.	Improved ore-sample grinder.
2	do.	Jones splitters.
1	do.	Sample mixer.

TABLE 22.- Hardware for sampling mill building

95	Pieces	No. 24 gage galvanized corrugated iron, 8 feet long.
42	do.	No. 24 gage galvanized corrugated iron, 7 feet long.
22	do.	No. 24 gage galvanized corrugated iron 10 feet long.
22	do.	No. 24 gage galvanized corrugated iron, 5 feet long.
16	Only	No. 4 sash with frames.
14	Pairs	Transom pivots.
4	Only	No. 2 H doors to form two double doors.
6	Pairs	T hinges, 8-inch size.

TABLE 23.- Transmission equipment (fig. 2), for sampling mill

		<u>Lower shaft</u>
1	Piece	1-11/16-inch cold-rolled steel shaft, 21 feet long.
4	Only	1-11/16-inch common flat split boxes.
1	do.	16- by 8-inch S. F. split steel pulley, 1-11/16-inch bore.
1	do.	12- by 12-inch S. F. split steel pulley, 1-11/16-inch bore.
1	do.	4- by 4-inch C. F. split steel or wood pulley, 1-11/16-inch bore.
1	do.	10- by 10-inch C. F. split steel pulley, 1-11/16-inch bore.
1	do.	34- by 6-inch S. F. split steel pulley, 1-11/16-inch bore.
2	do.	1-11/16-inch split safety set collars.
		<u>Upper shaft</u>
1	Piece	1-15/16-inch cold-rolled steel shaft, 21 feet long.
4	Only	1-15/16-inch common flat split boxes.
2	do.	12- by 8-inch S. F. split steel pulleys, 1-15/16-inch bore.
2	do.	36- by 6-inch C. F. split steel pulleys, 1-15/16-inch bore.
1	do.	6- by 5-inch C. F. split steel pulley, 1-15/16-inch bore.
1	do.	12- by 10-inch C. F. split steel pulley, 1-15/16-inch bore.
2	do.	1-15/16-inch split safety set collars.
1	do.	34- by 12-inch C. F. split steel pulley, 1-15/16-inch bore.
1	do.	16- by 8-inch S. F. split steel pulley, 1-15/16-inch bore.
		<u>Transmission belting</u>
		Conveyor.....No. 1.....30-foot, 4-inch, 4-ply.
		Sampler.....No. 1.....22-foot, 3-inch, 4-ply.
		Feeder.....20-foot, 3-inch, 4-ply.
		Rolls.....58-foot, 6-inch, 4-ply.
		Sampler.....39-foot, 3-inch, 4-ply.
		Countershaft.....28-foot, 10-inch, 4-ply.
		Conveyor.....29-foot, 4-inch, 4-ply.
		Grinder.....23-foot, 6-inch, 4-ply.
		Mixer.....19-foot, 4-inch, 4-ply.
		Braun.....20-foot, 2-inch, 4-ply.
		Engine or motor.....50-foot, 12-inch, 5-ply.
		Compressor.....20-foot, 2-inch, 4-ply.
		<u>Summary of belting</u>
		40 feet 2-inch 4-ply.
		81 feet 3-inch 4-ply.
		78 feet 4-inch 4-ply.
		81 feet 6-inch 4-ply.
		29 feet 10-inch 4-ply.
		50 feet 12-inch 5-ply.

TABLE 24.- Cost of sampling mill (fig. 8)

Timber, including construction, 5,000 board feet at \$50 per thousand (table 20).....	\$ 250.00
Hardware in place (table 22).....	294.00
Primary No. 1 Vezin sampler, weight 600 pounds.....	300.00
Freight and hauling.....	25.00
Erection and supports.....	25.00
Drive.....	25.00
Surge bin, erected.....	50.00
12-inch rack and pinion gate, erected.....	25.00
14-inch belt feeder, erected.....	125.00
1 set 18- by 10-inch "Economic" rolls, weight 4,700 pounds.....	900.00
Freight.....	100.00
Erection.....	125.00
Drive.....	100.00
Discharge chutes.....	75.00
Secondary Vezin sampler.....	300.00
Freight and hauling.....	25.00
Erection and supports.....	20.00
Drive.....	25.00
Improved sample grinder.....	200.00
Freight.....	50.00
Foundation and erection.....	25.00
Drive.....	20.00
Sample mixer, weight 250 pounds.....	100.00
Freight.....	15.00
Drive.....	15.00
Braun pulverizer.....	135.00
Freight.....	10.00
Drive.....	10.00
Air compressor.....	78.00
Receiver and pipe.....	22.00
Installation.....	10.00
Chutes for all rejects, erected.....	150.00
Jones splitters, 2 at \$26 each.....	52.00
40-hp. motor, 1,160-r.p.m., complete with pulley and slide rails, switch and starter.....	440.00
Lineshaft, pulleys, etc. (table 23).....	250.00
Erection.....	125.00
Belting (table 23).....	80.00
30 interior 50-watt lamps with sockets and switches.....	)
Interior light wires to be installed in metal conduit.....	) 200.00
10 yards lights, wiring, and sockets to be weatherproof.....	)
Total.....	4,776.00

TABLE 25.- Timber list for conveyor gallery to storage bins (fig. 10)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
12	6 by 10	16	Inclined stringers	960
10	2 by 6	14	Joists	140
2	2 by 6	18	do.	36
2	2 by 6	14	Beams	28
2	6 by 6	20	do.	120
2	2 by 8	14	Sway braces	37
50	2 by 12	14	Floor	1,400
18	2 by 4	14	Posts	168
3	2 by 4	16	do.	32
2	4 by 4	16	do.	43
20	2 by 4	18	Trusses	240
8	2 by 4	12	do.	64
1	8 by 8	16	Bent 1	85
1	6 by 8	10	do.	40
1	8 by 8	16	Bent 2	85
1	6 by 8	14	do.	56
2	2 by 8	14	do.	37
1	8 by 8	20	Bent 3	107
2	6 by 8	14	do.	112
2	4 by 8	14	do.	75
2	2 by 8	18	do.	48
1	8 by 8	22	Bent 4	117
2	6 by 8	18	do.	144
2	4 by 8	18	do.	96
2	2 by 10	22	do.	73
1	8 by 8	20	Bent 5	107
1	8 by 8	14	do.	75
1	6 by 8	20	do.	80
2	6 by 8	12	do.	96
1	4 by 8	20	do.	53
2	4 by 8	14	do.	75
4	2 by 8	18	do.	96
12	4 by 6	18	Conveyor stringers	432
12	2 by 4	18	do.	144
3	2 by 6	18	Cross braces	54
Total feet, board measure				5,555

TABLE 26.- Hardware for conveyor gallery to storage bins

12	Only	4-light sliding sash (10- by 12-inch lights), without frames.
133	Pieces	No. 24 gage galvanized corrugated iron, 8 feet long.
15	do.	No. 24 gage galvanized corrugated iron, 6 feet long.
86	do.	No. 24 gage galvanized corrugated iron, 5 feet long.
110	Feet	No. 24 gage galvanized ridge roll.
10	Pieces	1-inch W. I. pipe, 1 foot long, for dowels for trestle bent foundations.

TABLE 27.- Equipment for conveyor to storage bins (fig. 10)

1	Only	Conveyor 16-inches wide by 103-feet long, to consist of:
1	do.	18- by 18- by 1-15/16-inch bore rubber-covered headpulley with shaft and automatic holdback.
1	do.	23.89-inch P. D. gear, 1-inch pitch, 2-1/2-inch face, 1-15/16-inch bore.
2	do.	1-15/16-inch common flat split boxes.
2	do.	1-15/16-inch split set collars.
1	do.	5.12-inch P. D. pinion, 2-3/4-inch face, 1-inch pitch, 1-7/16-inch bore.
1	do.	30- by 4-inch C. F. split steel pulley, 1-7/16-inch bore.
2	do.	1-7/16-inch common flat split boxes.
2	do.	1-7/16-inch split set collars.
1	do.	18- by 18-inch tail pulley, 1-15/16-inch bore, complete with shaft.
2	do.	1-15/16-inch split set collars.
1	Pair	1-15/16-inch take-ups, 9-inch travel.
20	Only	16-inch 3-roll troughing idlers complete with grease cups.
11	do.	16-inch return idlers complete with grease cups.
212	Feet	16-inch wide, 4-ply, 28-ounce duck, 1/8-inch top rubber cover, 1/32-inch bottom rubber cover, medium grade.
12	Only	3/4-inch bolts, 16 inches long.
12	do.	3/4-inch O. G. washers.

TABLE 28.- Cost of conveyor and conveyor gallery to storage bins (fig. 10)

Excavation.....	\$ 5.00
Concrete, 2-1/2 cubic yards at \$12 per cubic yard.....	30.00
Timber, including construction, 5,600 board feet at \$50 per thousand (table 25).....	280.00
Corrugated iron, 27 squares at \$5.50 each (table 26).....	148.00
Laying at \$1.75 per square.....	47.00
Sashes, 16 at \$4 each, in place (table 26).....	64.00
Door with hardware.....	15.00
16-inch conveyor (table 27).....	800.00
Erection.....	70.00
5-hp. motor, geared, complete with switch and starter.....	257.00
Erection and wiring.....	20.00
Total.....	1,736.00

TABLE 29.- Timber list for storage bins (fig. 11)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
2	8 by 10	22	Sills	293
1	8 by 8	8	do.	43
10	8 by 8	12	Posts or columns	640
2	8 by 8	22	do.	235
1	8 by 8	8	do.	43
3	6 by 10	22	Beams	330
4	6 by 10	14	do.	280
7	6 by 8	12	Front verticals	336
10	6 by 8	12	Back verticals	480
4	6 by 8	16	Horizontals	256
3	6 by 8	20	do.	240
2	6 by 8	14	End horizontals	112
1	6 by 6	16	do.	48
1	6 by 8	16	do.	64
1	6 by 8	10	do.	40
1	6 by 8	16	End vertical	64
4	6 by 8	12	do.	192
1	4 by 8	16	do.	43
1	4 by 6	10	do.	20
7	6 by 10	16	Bin bottom beams	560
4	4 by 8	14	Diagonal braces	149
4	4 by 12	14	Bin bottom, Bin B	224
3	4 by 12	12	do.	144
4	4 by 10	18	Bin bottom, Bin C	240
2	6 by 6	16	Horizontal tie, Bin C	96
1	6 by 6	18	do.	54
2	6 by 6	16	Track runway	96
3	4 by 6	16	Track joists	96
8	3 by 6	18	Bottom cleats	216
2	6 by 8	14	Top ties	112
1	6 by 6	16	Top beams	48
36	2 by 12	16	Lining, Bin A	1,152
9	2 by 12	20	do.	360
5	2 by 12	20	Lining, Bin B	200
10	2 by 12	16	do.	320
21	2 by 12	18	Lining, Bin C	756
4	2 by 4	16	Handrail	43
7	2 by 12	16	do.	224
			Total feet, board measure	8,849

TABLE 30.- Hardware for storage bins (fig. 11)

1	Only.....	Pipe clamp, complete with bolts, as shown.
1	Piece.....	10-inch diameter, st. W. I. pipe, 10 feet long.
40	Linear feet	3/16-inch plate, 10 inches wide, punched 3/8-inch holes for spikes for chute lining.
2	Only.....	1-inch tie rods, 7 feet 6 inches long, 4-inch thread each end.
50	Feet.....	3/4-inch round mild steel for bolts.
42	Only.....	3/4-inch O. G. washers.
42	do.	3/4-inch nuts (square).
4	do.	1-inch O. G. washers.
4	do.	1-inch nuts (square).
2	do.	24-inch wide arc gates, complete with bearings.
2	do.	18-inch wide arc gates, complete with bearings. a/

a/ Deduct one 18-inch gate and 15 linear feet 3/16-inch plate, 10 inches wide, if bin B is not built.

TABLE 31.- Cost of storage bins (fig. 11)

Excavation.....	\$ 5.00
Concrete, 3.55 cubic yards at \$12 per cubic yard.....	42.00
Timber, including construction, 9,000 board feet at \$50 per thousand (table 29).....	450.00
24-inch arc gates, erected, 2 at \$15.....	30.00
18-inch arc gates, erected, 2 at \$12.....	24.00
Hinged chutes, erected, 2 at \$20.....	40.00
Pipe chute to bin B, with clamps.....	20.00
Bolts, rods, and washers.....	25.00
Distributing chutes.....	25.00
Total.....	661.00

TABLE 32.- Timber list for ore storage platform and trestle (fig. 1)

Number of pieces	Size, inches	Length, feet	Where used	Feet, board measure
15.....	6 by 6	14	Parts for bents.....	630
16.....	6 by 8	12	Stringers for bents.....	768
5.....	6 by 8	12	Caps for bents.....	240
2.....	6 by 8	16	do.	128
4.....	4 by 6	14	Sills.....	112
2.....	4 by 6	16	do.	64
8.....	2 by 8	16	Braces.....	171
18.....	4 by 6	12	Ties.....	432
8.....	2 by 12	12	Walk.....	192
4.....	4 by 6	12	Sills for platform.....	96
36.....	2 by 12	12	Floor.....	864
16.....	2 by 12	12	Front and back walls of platform.....	384
Total feet, board measure.....				4,081

TABLE 33.- Cost of ore-storage platform and trestle (fig. 1)

Timber, including construction, 4,000 board feet at \$50 per thousand (table 32).....	\$ 200.00
Rails, 12-pound, 200 feet, 800 pounds at \$0.04.....	32.00
Total.....	232.00

TABLE 34.- Cost of accessory equipment

Platform scale, steel, 22 by 9 feet, weight 5,400 pounds.....	\$ 621.00
Freight.....	110.00
Platform, 600 feet, board measure, at \$50 per thousand.....	30.00
Pit excavation, 28 cubic yards at \$1 per cubic yard.....	28.00
Pit excavation, 8 cubic yards at \$12 per cubic yard.....	96.00
Erection.....	75.00
Scale house.....	25.00
Shop and oil-storage house, 10- by 20- by 10-foot building, timber and corrugated iron construction.....	125.00
Sundry tools, saws, hammers, Stillson wrenches, etc.	100.00
Electric hot-plate dryer.....	40.00
Transformers and fused cutouts.....	482.00
Two-pole transformer station with cross arms and platform.....	45.00
Distribution poles in yard.....	75.00
Mine car, 20-cubic-foot, roller bearing.....	100.00
Total.....	1,952.00

TABLE 35.- Summary of timber lists a/

<u>Structure</u>	<u>Table number</u>	<u>Figure number</u>	<u>Board feet</u>
Approach to receiving bins.....	7	3	36,680
Receiving bins.....	10	4	7,933
Conveyor gallery to sampling mill..	16	6	5,922
Sampling mill.....	20	7	4,804
Conveyor gallery to storage bins...	25	10	5,555
Storage bins.....	29	11	b/8,849
Storage platforms.....	32	1	4,081
Total board feet.....			73,824

a/ Timber required for the sampling works (except assay office).

b/ If bin B is not constructed, deduct 1,184 board feet.

TABLE 36.- Summary of costs

	Table number	Cost
Assay office.....	6	\$2,045.00
Approaches to receiving bins.....	9	2,606.00
Receiving bins.....	12	1,031.00
Crusher and pit.....	15	2,252.00
Conveyor to sampling mill and gallery.....	19	1,871.00
Sampling mill.....	24	4,776.00
Conveyor to storage bin and gallery.....	28	1,736.00
Storage bins.....	31	661.00
Ore storage platform and trestle.....	33	232.00
Accessory equipment.....	34	1,952.00
Total.....		19,162.00
Contractor's profit, 10 percent.....		1,916.00
Engineering and supervision, 5 percent.....		958.00
Grand total cost of complete sampling plant.....		22,036.00

The foregoing estimates were made for first-class construction and equipment throughout the plant on the most costly type of site for the construction of the plant; the design is for the most efficient operation of the works.

With Diesel-electric power, the cost would be increased by \$2,981 (\$3,633 minus \$652), and with direct drives by two gasoline engines converted to use fuel oil, by \$623, (\$2,154 plus \$445 minus \$1,976). If two gasoline engines were used for power, the total cost would be decreased by \$611 (\$1,976 minus \$920 minus \$445). A further saving of \$257 could be made by driving the conveyor to the storage bin from the line shaft.

A considerable saving in the cost of the ramps could be obtained with the same standards if the receiving bins were built on a hillside location. Moreover, if the trucks, after being unloaded, were required to back down, about 40 percent (\$1,000) of the cost of the approaches to the receiving bins could be saved. Should the receiving bins be eliminated from the flow sheet, the costs of the ramp (\$2,606) and of the receiving bins (\$1,031) could be saved, with the additional expense of a short earth ramp and a platform, amounting to about \$200 - a net saving of \$3,437.

A further saving of about \$2,850 could be effected by using bucket elevators instead of belt conveyors. A bucket elevator for the service required with the necessary housing, would cost \$480 erected. Bucket elevators for this service are not recommended by the authors, however.

A plant driven by two gasoline engines, with no receiving bins, and two bucket elevators would cost:

Sampling mill.....	\$4,776.00
Crusher and pit.....	2,252.00
Storage bins and platform.....	893.00
Two bucket elevators.....	960.00
Accessory equipment.....	1,952.00
Assay office.....	2,045.00
	12,878.00
Saving by using gasoline engines.....	611.00
	12,267.00
Contractor's profit, 10 percent.....	1,227.00
Engineering and supervision, 5 percent	613.00
Total.....	14,107.00